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DATA REPORT: COBLAMED '76 TETHERED BUOY EXPERIMENT.(U)
OCT 77 E R LEVINE, L GOODMAN, D H SHONTING
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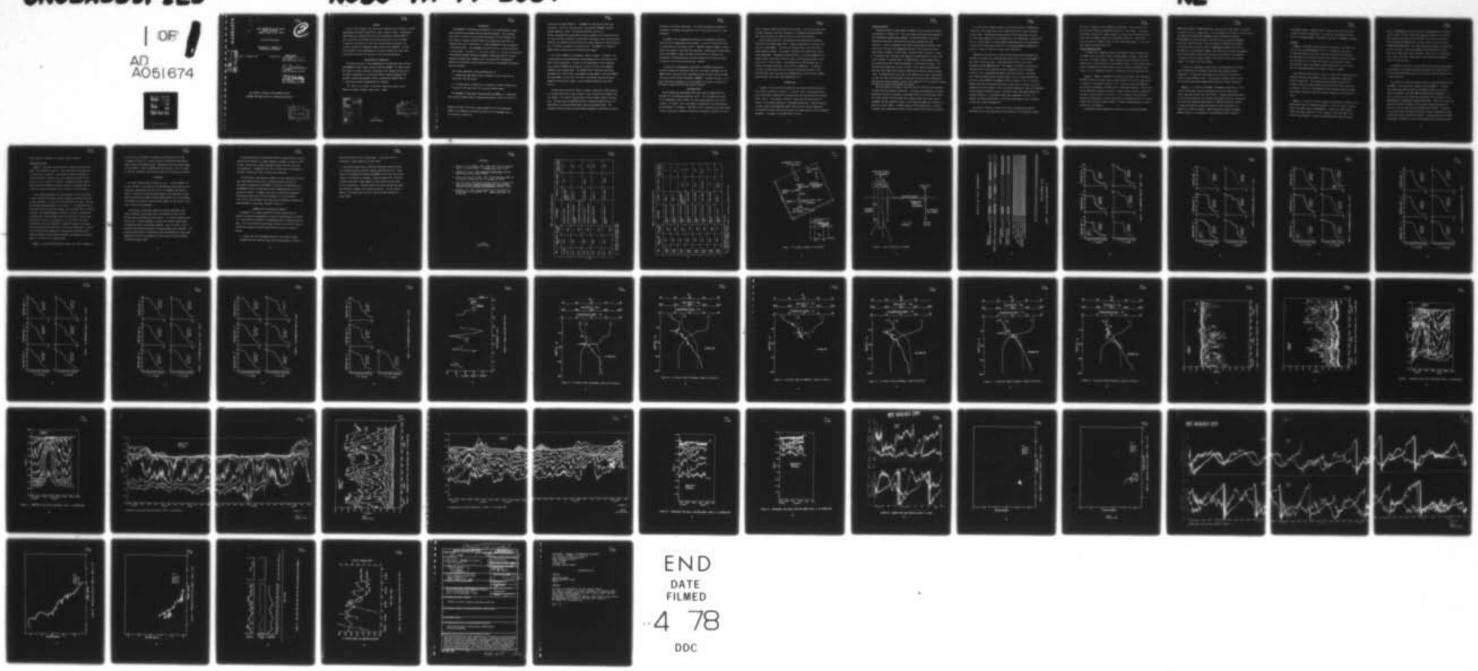

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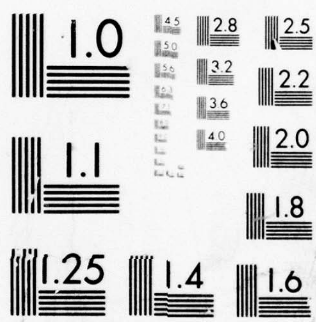

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NAVAL UNDERWATER SYSTEMS CENTER
NEWPORT LABORATORY
Newport, Rhode Island 02840

Technical Memorandum

DATA REPORT: COBLAMED '76 TETHERED BUOY EXPERIMENT

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Date: 3 October 1977

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ABSTRACT

From 10 to 25 September 1976, upper ocean temperature and horizontal current measurements were made in the Gulf of Lyons, south of Toulon. Simultaneous moored data were obtained from the fixed oceanographic platform BORHA II and a satellite buoy tethered at horizontal separations from 100-1000m. In addition, time series of wind, other meteorological parameters, and vertical conductivity-temperature-depth profiles were obtained. The data set presented in this memorandum will be used to examine the upper ocean internal wave field and its relation to local forcing mechanisms.

ADMINISTRATIVE INFORMATION

The effort described in this memorandum was accomplished under Contract N001477WR70051, "Upper Ocean Variability During COBLAMED '76," NORDA 410/ONR 481 Sponsor Ed Lange, Principal Investigator Louis Goodman and Associate Principal Investigator E.R. Levine, and Contract 62755 UF 52552101, "ASW and Naval Systems Environmental Studies, Oceanography," NAVSEA Sponsor J. Ropeck and Principal Investigator D.H. Shonting.

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INTRODUCTION

The COBLAMED '76 tethered buoy experiment is an investigation of upper ocean structure and dynamics during strong wind changes. The experiment took place in the Gulf of Lyons during the period 10 to 25 September 1976. This region is suitably located (figure 1) to experience the effects of offshore winds such as the mistral, a strong northwesterly flow originating in the Rhone Valley. This COBLAMED (Cooperation Autour La Bouée Laboratoire à Mediterranée) experiment is the most recent in a series of cooperative investigations between the ASW Environmental Technology Group of the Naval Underwater Systems Center (Newport, RI), the Laboratoire Oceanographie Physique of the Museum d'Histoire Naturelle (Paris), and SACLANT ASW Research Center (La Spezia).

The primary objectives of the experiment were to:

1. Examine the upper ocean (0-50 m) response to local winds such as the mistral and the sirocco.

2. To study oceanic variability as it relates to inertio-internal wave structure of the upper layer of the western Mediterranean.

The COBLAMED '76 experiment centered around the BORHA II, a stable deep water platform (2400 m) which is three-point moored* at 42° 15' N 05° 35' E

*Because of anchor line failure several months prior to the experiment BORHA II was tethered by two mooring cables until 22 September when it was joined to a third line.

in the Gulf of Lyons (figure 1). The BORHA II is the second French buoy laboratory. The first buoy laboratory was used for COBLAMED '69 observations (Shonting, 1974). The platform (figure 2) serves as a moored oceanographical-meteorological station, complete with living facilities for eight crew and scientists, an electronics laboratory, shop, and observation platform. This 900-metric-ton platform has a heave frequency of several minutes, and is virtually unresponsive to surface waves. The BORHA II is funded by CNEXO (Conseil National pour L'Exploration des Oceans).

The overall COBLAMED '76 experiment, shown in figure 1, included a line of three buoys placed perpendicular to the probable path of the mistral wind (NW) at 25 km separations. On each of the French buoys, vector averaging current meters (VACMs) were placed at 5 m and 55 m with a 50 m Aanderaa thermistor chain between them. The SACLANT Center subsurface mooring was equipped with a float at 20 m, two Aanderaa current meters at 25 m and 1000 m, and three VACMs at 30 m, 60 m, and 120 m; the SACLANT taut mooring had an Aanderaa current meter at 1000 m and an Aanderaa thermistor chain from 10-110 m.

The NUSC satellite buoy for Phase I (figure 2) (Sept. 9-19, 1976) consists of a surface toroid with a mast to which a radar reflector and a marker light are attached. For Phase II (Sept. 22-30), a 50-cm-diameter surface float was used. The buoys were instrumented with an 11-thermistor Aanderaa chain (5 m separations), a Braincon current meter, and a 50 kg weight below. The thermistor chain was hung at various depths depending on the highly variable

thickness of the local mixed layer. The satellite buoys were tethered to the BORHA II by buoyant polypropylene line at horizontal separations from 100-1000 m.

The BORHA II was instrumented with two 20 m long Aanderaa thermistor chains (with 2 m separations) during Phase I; or one 50 m long chain (with 5 m separations) during Phases I and II. Whenever possible, Aanderaa current meters were placed in the mixed layer and below. Meteorological measurements made on the BORHA included wind speed and direction, air pressure, air temperature, cloud observations, relative humidity and incident radiation. In addition, wave height and period were recorded.

In addition to oceanographic measurements, SACLANTCEN conducted an acoustic transmission experiment using a 3.5 kHz source suspended from the BORHA II and a receiving array suspended from the R/V Maria Paolina G (MPG). This ship and the Italian minesweeper, MAGNAGHI, provided CTD casts in the upper ocean while underway (yo-yo's) and deeper CTD profiles, respectively. Horizontal velocity profiles were taken by the MPG.

INSTRUMENTATION

Moored temperature measurements were made using the Aanderaa Profile Recorder TR-1 and Aanderaa thermistor chains. The instruments were used in the temperature range 10^{o}-36^{o}C, for which the manufacturer specified an accuracy of 0.03^{o}C. For a step change in temperature, the time constant of the system is 3.5 minutes. Sampling of the 11 thermistors was done sequentially at two-minute intervals, and data are recorded in the form of 10-bit

words on magnetic tape using short and long pulses. Prior to the experiment, the NUSC thermistor chain was calibrated in a temperature-controlled water bath and the accuracy was found to match the above specifications.

Current speed, direction, and temperature were measured with Aanderaa Recording Current Meter Model RCM 4. Speed was measured by a Savonius rotor driving a potentiometer. Direction was obtained using a vane and fluid-damped magnetic compass. The system is equipped with a thermistor used to sense temperature. Information from each sensor is recorded sequentially on magnetic tape at two-minute intervals using a self-balancing bridge circuit which drives a rotary encoder. The manufacturer's specifications are $\pm$ 5 degrees for current direction, and $\pm$ 0.1°C for temperature. In addition, a Braincon current meter with an inclination sensor was attached to the satellite buoy, but it was physically damaged due to collision with a BORHA mooring cable, and no data were obtained from it.

OBSERVATIONS

A summary of the observation sequence of data taken during the satellite buoy study is presented in figure 3. In tables 1 and 2, simultaneous data at various horizontal separations are tabulated for the two observational periods, Phase I and II. These tables include all usable data not affected by bit dropout in the Aanderaa systems, or instrument malfunction. The data obtained included conductivity-temperature-depth (CTD) profiles, moored temperature and horizontal current velocity time series, and meteorological and environmental parameters. A summary of the observations follows.

Vertical Profiles

Temperature profiles taken aboard the BORHA II with a Plessey CTD system are presented in figures 4-11. Since the conductivity sensor was inoperable, only temperature profiles were obtained. At 2150 GMT/10/Sept a two-layer structure occurs after a period with wind speeds exceeding 15 m/sec (figure 4). During a subsequent rapid drop in wind speed and change in wind direction to the east, the temperature gradient at the base of the mixed layer begins to weaken at 1215/11/Sept. By 2130/11/Sept, following a period of increasing winds, the mixed layer deepens to approximately 45 m, and a two-layer structure is reestablished. By 0835/14/Sept, surface heated effects have warmed the surface layer, and resulted in a three-layer structure. This structure has eroded into a series of small ($\sim$ 3m) steps with warming below the mixed layer from 20-70 m depth by 1620/14/Sept, during a period of weaker winds. An explanation for this data is the advection of a warm, shallow mass of water (of order 10 km horizontal scale) past the sensor until 1405/16/Sept when the three-layer structure returns. This hypothesis will be checked by looking at other data taken by our European colleagues.

During the period 15-17/Sept, a mistral occurred, bringing winds exceeding 18 m/sec from the northwest (figure 34). The upper ocean temperature structure approached a three-fluid system on 2015/16/Sept with a 28 m mixed layer depth. This occurs during the period where the strongest winds occur, and is not in agreement with the classical picture of wind deepening shown, for instance, by Krauss and Turner (1967). On 2210/17/Sept, during lighter winds ($\sim$ 5 m/sec), the mixed layer exceeds 40 m and the 3-layer structure evolves into two layers.

In a more rapidly sampled sequence of profiles beginning at 0700/25/Sept (figure 8), a 28 m mixed layer, with a temperature 21.1°C, occurs following 10 m/sec winds. During the following 30 hours, winds diminished to 4 m/sec. The mixed layer warmed by 1°C, and shoaled to 3 m by 1253/26/Sept (figures 8-10). This is a clear example of surface heating dominating mixed layer development. A time series of mixed layer depths for all available BORHA CTD temperature profiles is shown in figure 12; values range from 5-48 m.

Temperature, salinity and σ_T profiles taken aboard the R/V Magnaghi are presented in figures 13-18. These data were taken within 10 Km of the BORHA II with a Neil Brown CTD system. These temperature profiles are in good agreement with the BORHA profiles. For example, on 17/Sept, the three-layer structure shown in both profiles and their temperatures are in agreement (figures 5, 13). On 18/Sept, the overall profiles are similar, including small scale variability below the mixed layer, but a 5 m step observed from the ship is not evident in the BORHA II profile (figure 6, 14). On 22/Sept, however, step-like structure below the 40 m mixed layer is evident in both CTD temperature profiles (figure 7, 16), and surface temperature values are comparable. Surface heating on 23/Sept results in the small upper mixed layer temperature gradient (figures 7, 17) and warmer mixed layer temperature (21.7°C). On 25/Sept, the shallow mixed layer (< 30 m) with small steps below is indicated in both sets of data (figures 8, 18).

The spikes in the CTD salinity profiles are instrumental, related to differences in the time constants of the conductivity and temperature sensors,

and occur in regions of strong temperature gradients. The σ_T profiles are most strongly affected by temperature structure in this region. They show a three-layer structure on 17/Sept (figure 13), a step-like structure below the mixed layer on 18/Sept (figure 14) and 22/Sept (figure 16). A quasi-two-layer structure on 23/Sept (figure 17) and a small mixed layer ($\sim$ 15 m) with steps below on 25/Sept (figure 18).

Moored Temperature Data

In figures 19-27, temperature data from thermistor chains suspended from the BORHA II and the satellite buoy, the Bebe BORHA, are shown. These data have been run through a quality control program to eliminate points with bit dropout due to faulty operation of the Aanderaa encoder. In the program, data points are compared with earlier points, and if a critical difference value (usually $1^{o}C$) is exceeded, the point is replaced by the last good data value.

Phase I - BORHA II temperature time series from Phase I were recorded at two meter vertical intervals from 10-12/Sept (figures 19, 20) and later during 17-19/Sept at 5 m spacing (figures 21, 22). These data show high frequency oscillations superimposed on longer period (10-20 hours) features. These longer period temperature changes are usually in phase through the local thermocline. The local inertial period is 17.9 hours. On the crests of the long period temperature fluctuations, we often see bursts of intermediate period (1-2 hours) changes with narrow band energy content, as shown on 0000-0400 GMT on 19/Sept (figure 22), for example.

Simultaneous moored temperature data taken at 5 m spacing aboard Bebe

BORHA during Phase I at 1000 m and 600 m long separations from BORHA II are shown in figures 23 and 24, respectively. The low frequency oscillations in those records are generally in phase with the BORHA II data, correspond to vertical displacements of order ten meters, and often display a wavelike appearance with a near-inertial period. Since the Endeco current meter was damaged during the mistral, we do not have an independent estimate of the tilt of the moorings. We do believe, however, that these large vertical displacements during this period of strong winds are due to oscillations of the mooring in response to local current changes. A discussion of the local current regime is included in the next section.

In figure 23, temperature records show a rapid deepening of the mixed layer to below 36 m on 9-10/Sept, where NW winds exceeded 18 m/sec (figure 34). In figure 24, once again we see trains of 1-2 hour oscillations on low frequency crests. The data were recorded at the tail end of the Mistral when winds dropped from 18 m/sec to 5 m/sec (figure 34).

<u>Phase II</u> - In figure 25, the BORHA II temperature time series, for 5 m vertical separations, show less pronounced long scale features than Phase I data with periods less than 14 hours. Another interesting feature is the diurnal periodicity of the mixed layer depth, with four shoalings of the mixed layer appearing approximately at 1000 GMT through the record. It should be noted that winds were generally lower during Phase II, peaking at 13 m/sec on 24/Sept. Moored temperature records from Bebe BORHA in Phase II are limited due to intermittent encoder problems in

the Aanderaa system. Figures 26 and 27 show satellite buoy time series at 100 m and 300 m, respectively. In figure 26, the large oscillations at 47 m on 23/Sept resemble simultaneous features in the BORHA II records.

Currents

Phase I - Horizontal current velocity was measured in the mixed layer (29.5 m) and in the thermocline (71.5 m). In figure 28, time series of speed and direction are shown, and current direction at both levels are dominated by oscillations near the local inertial period (17.9 hours). Current speed at 71.5 m reaches 40 cm/sec at one point, has a strong near-inertial signal, and exceeds current speed at 29.5 m at all times. At 29.5 m the maximum speed, 23.5 cm/sec, occurs on 11/Sept.

These data were taken during a period of strong winds reaching 18 m/sec, changing direction from northwest to east, accompanied by dropping air pressure (figure 34). The progressive vector diagram for the 29.5 m currents (figure 29) shows clockwise circulation with a small mean drift to the east. At 71.5 m, the progressive vector diagram (figure 30) shows two clockwise loops and a mean drift to the southeast for the forty-hour record.

Phase II - In figure 31, current speed and direction are plotted for 10 m (mixed layer) and 50 m (thermocline) depths. At the 10 m level, a maximum speed of 33 cm/sec occurs at 0800/30/Sept. Progressive vector diagram (figure 32) shows a mean drift to the southeast with three loops of 4-, 8-, and 12-hour duration. At 50 m, the maximum current speed (25 m/sec)

occurs at 2200/25/Sept, during a period of decreasing winds ($\sim$ 5 m/sec) from the south. The 50 m time series shows oscillations in both speed and direction at periods near the inertial in the first half of the record 1800/Sept/24-0600/Sept/27, and then later on during the period 1500/Sept/28-1000/Sept/29. The progressive vector diagram for these data (figure 32) shows a complicated looping pattern during the first 68 hours and an additional loop at 100 hours. Mean drift is to the south-east at 50 m, with total translation in that direction approximately 45% of the drift at 10 m.

In comparison with Phase I current data (which was taken under severe wind conditions and showed increasing mean current with depth) Phase II currents showed increased mean drift in the mixed layer and lower values in the thermocline.

During Phase II, while the satellite buoy was tethered 250-400 m from the BORHA II, the buoy itself rotated around the BORHA II. To study these motions, records were kept of the magnetic bearing of the buoy relative to BORHA II from 1443 (GMT) 23/Sept through 2305/26/Sept. A plot of bearing vs time (figure 35) shows almost three rotations of the Bebe BORHA from 1200/23/Sept through 1200/25/Sept. After this period, the bearing oscillation continued, but the angular spread decreased with each cycle, and the buoy oscillated between 100° and 290°. The period of oscillation over the 80-hour period was 18 hours, approximately equal to the local inertial period (17.8 hours). During the periods of highest wind speeds, the motion is rotary; with decreasing wind speed the rotary

motion appears to weaken or the "mean" current dominates.

METEOROLOGICAL DATA

Phase I - Wind speed, direction and air pressure time series for Phase I are plotted in figure 34. Wind speed peaks on 10/Sept after a 12 mb drop in air pressure. This period was marked by decreasing relative humidity, clearing skies, and average wave height (for 80 waves) of 6.5 m, periods of 5 seconds. Although winds were predominantly from the northwest during this interval, the weather does not qualify as a bona fide Mistral due to variation in wind direction.

In the following periods, wind speed dropped to zero at 0700 GMT/ 11 Sept, and the wind direction rapidly changed and entered the south and east quadrants. At this time relative humidity was low ($\sim$50%) and wave heights decreased rapidly to less than 1 m. By 0200 GMT/13/Sept, wind direction had shifted to northwest, and wind speed and air pressure increased. At 1000 GMT/15/Sept, the Mistral arrived, a strong north wind which blew down the Rhone valley into the Gulf of Lyons, and was characterized by cold, dry conditions. At this point, wind speed increased to 9 m/sec (at 1300 GMT it reached 14 m/sec), air pressure rose, and wind direction was fixed in the interval 290°-320°. Throughout the Mistral, which lasted until approximately 1600 GMT/17/Sept, relative humidity was low (typically 55-65%), and average wave heights reached 6.5 m with 4 sec average periods.

Phase II - Available meteorological data at the time of preparation

of this report was limited to intermittent wind speed and direction information (figure 34). During the period 1443/23/Sept-1800/25/Sept, winds from the SE exceeded 10m/sec. Subsequently, the wind speed dropped to the minimum, 4 m/sec at 1200/26/Sept, and eventually rose to 7 m/sec at 0505 GMT on 27/Sept; wind direction during this interval was southerly.

DISCUSSION

The report presents data collected by NUSC during COBLAMED '76. We hope that this unique data set and complementary data obtained by the Laboratoire Oceanographie Physique, Paris, and SACLANT, ASW Research Centre, La Spezia, will help our understanding of the evolution of upper ocean structure during highly variable meteorological and sea conditions, which ranged from calm to 20 m/sec winds speeds, and seas states varying from 1-7 during the experiment.

In particular, future data reduction of moored temperature time series from Phase I must begin with an elimination of sensor motion effects before proceeding with data analysis. By careful comparison with CTD profiles, it may be possible to correct for variable sensor depth and determine depth of particular isotherms. Then, for Phase I and II, horizontal and vertical coherence of isotherm depths can be computed. This kinematic description of projections of the three-dimensional upper ocean temperature field will be compared with the universal spectra proposed by Garrett and Munk (1975).

The moored horizontal current meter data will undergo spectral analysis, with particular emphasis on rotary coherence estimates, in order to infer vertical internal wave energy propagation between the mixed layer and the thermocline. Accompanying this flux, we would hope to see changes in the local internal wave field or mixed layer properties.

The CTD profiles taken aboard the BORHA will be compared with similar data taken aboard the two ships to examine horizontal variability. For example, examination of the BORHA II profile at 1015 GMT/19/Sept 76 and MAGNAGHI profile at 1100z shows spatial inhomogenesties at a 2.7 km separation distance. In general, the vertical profiles show downward mixing during high winds (figure 34) between 12-14 and 18-19/Sept, 14-15, 16-17, and 19-20/Sept. Calm winds from 25-27/Sept were matched with sharp decreases in mixed layer thickness (figure 12).

COMMENTS ON THE FUTURE USE OF BORHA II

The BORHA II is a stable platform with unique capabilities for Eulerian time series measurements of oceanic and meteorological variables. It is also particularly useful for measurements with a tethered satellite buoy. Use of the satellite buoy to study horizontal and vertical scales of variability, however, met with some difficulties which are worthy of mention.

1. Current data from instruments mounted on the vertical cables suspended from the satellite buoys may be biased because of heaving

action of the buoy in the surface waves. A thin spar float is preferable to other spherical or donut shapes.

2. The satellite buoy lines up with the local mean current so that its instrumentation can register changes along the mean flow. These data can be compared with records from BORHA II, which then can provide scales of correlation or coherence. Since the upper layer is usually strongly stratified, slight change in sensor depth can cause large bias in correlations. The mean current can cause drag upon the sensor cable forming a catenary, and lifting the sensors. For this reason a depth or tilt sensor must be used to record the time variation of sensor depth.

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TABLE 1. DATA RECORDED DURING PHASE I

DATE	START TIME (GMT)	END TIME (GMT)	INSTRUMENT	PLATFORM	TETHER LENGTH	TOTAL RECORD LENGTH (hrs)
9/10/76	1330	--	Thermistor Chain	Bebe BORHA (Satellite buoy)	50 m	2
9/10	--	1530	Braincon Current Meter			
9/10	1330	--	2 Aanderaa thermistor chains	BORHA II	--	51*
9/12	--	1710	2 Aanderaa current meters			51
9/10	1840	--	Thermistor Chains	Bebe BORHA	1000 m	
9/13	--	1240	Braincon current meter			66*
9/15	1644	--	Aanderaa thermistor chain	BORHA II	--	95**
9/19	--	1430				
9/17	1353	--	Aanderaa thermistor chain	Bebe BORHA	600 m	53**
9/19	--	1934				

* 47 hours of simultaneous data
** 48 hours of simultaneous data

TABLE 2. DATA RECORDED DURING PHASE II

DATE	START TIME (GMT)	END TIME (GMT)	INSTRUMENT	PLATFORM	TETHER LENGTH	TOTAL RECORD LENGTH (hrs)
9/22/76 9/23	1736	0555	Aanderaa Thermistor Chain	BORHA II	--	12
9/23 9/26	1424	0900	Aanderaa Thermistor Chain	BORHA II	--	43
9/23 9/24	1424	0125	Aanderaa Thermistor Chain	Bebe BORHA (Satellite buoy)	100 m	11*
9/24 9/25	0709	1120	Aanderaa Thermistor Chain	Bebe BORHA	15 m	5*
9/24 9/25	1223	1545	Aanderaa Thermistor Chain	Bebe BORHA	400 m	27*
9/25 9/26	1545	2400	Aanderaa Thermistor Chain	Bebe BORHA	250-300 m	32.5*
9/26 9/26	0300	0900	Aanderaa Thermistor Chain	Bebe BORHA	15 m	6*
9/24 9/28	1445	***	Aanderaa Current Meters	BORHA II	**5 m **50 m	***

* Simultaneous data for these intervals
** Vertical depths on cable
*** Remained on BORHA II after Phase 2. Tape being returned to the French

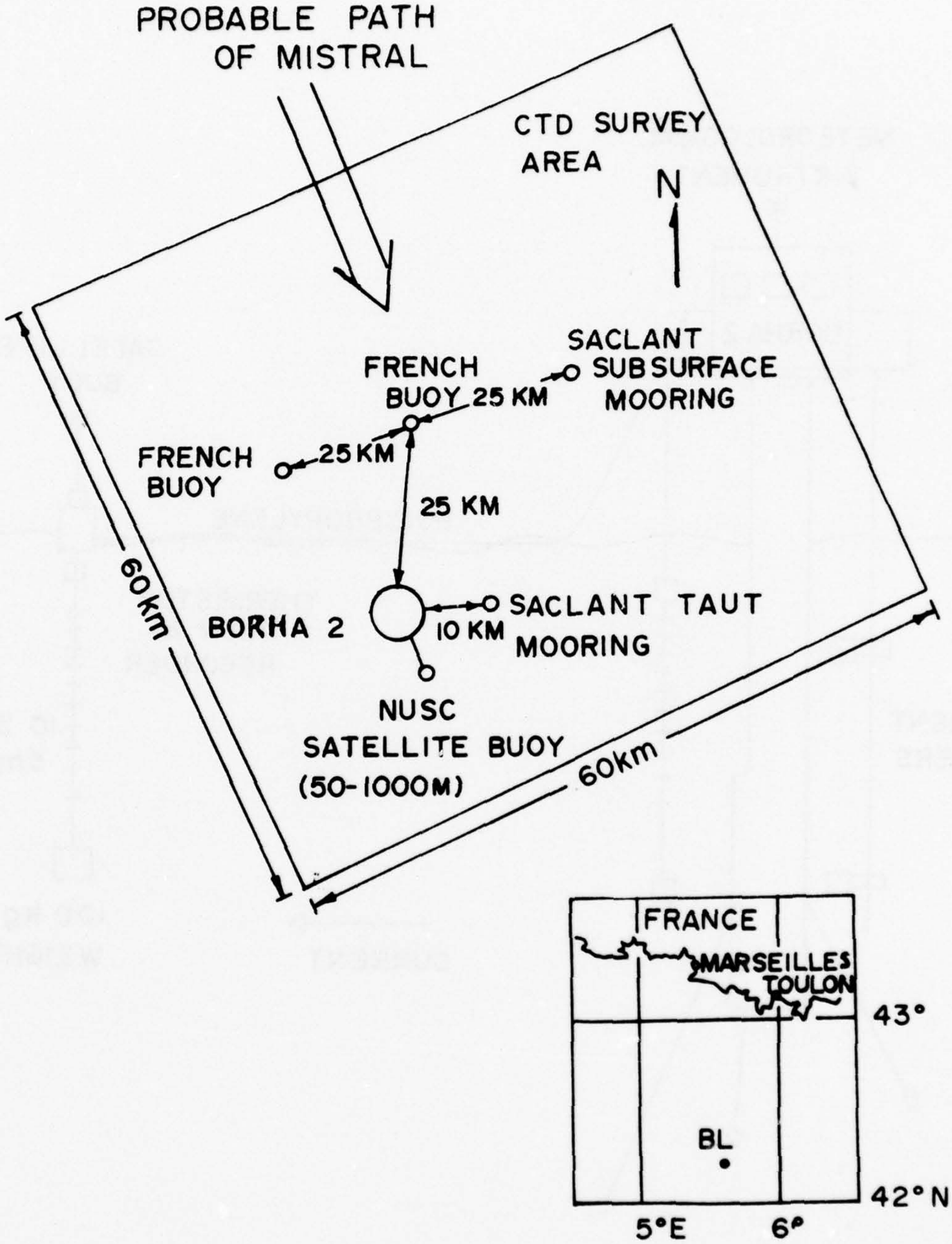


FIGURE 1. THE OVERALL COBLAMED '76 EXPERIMENT

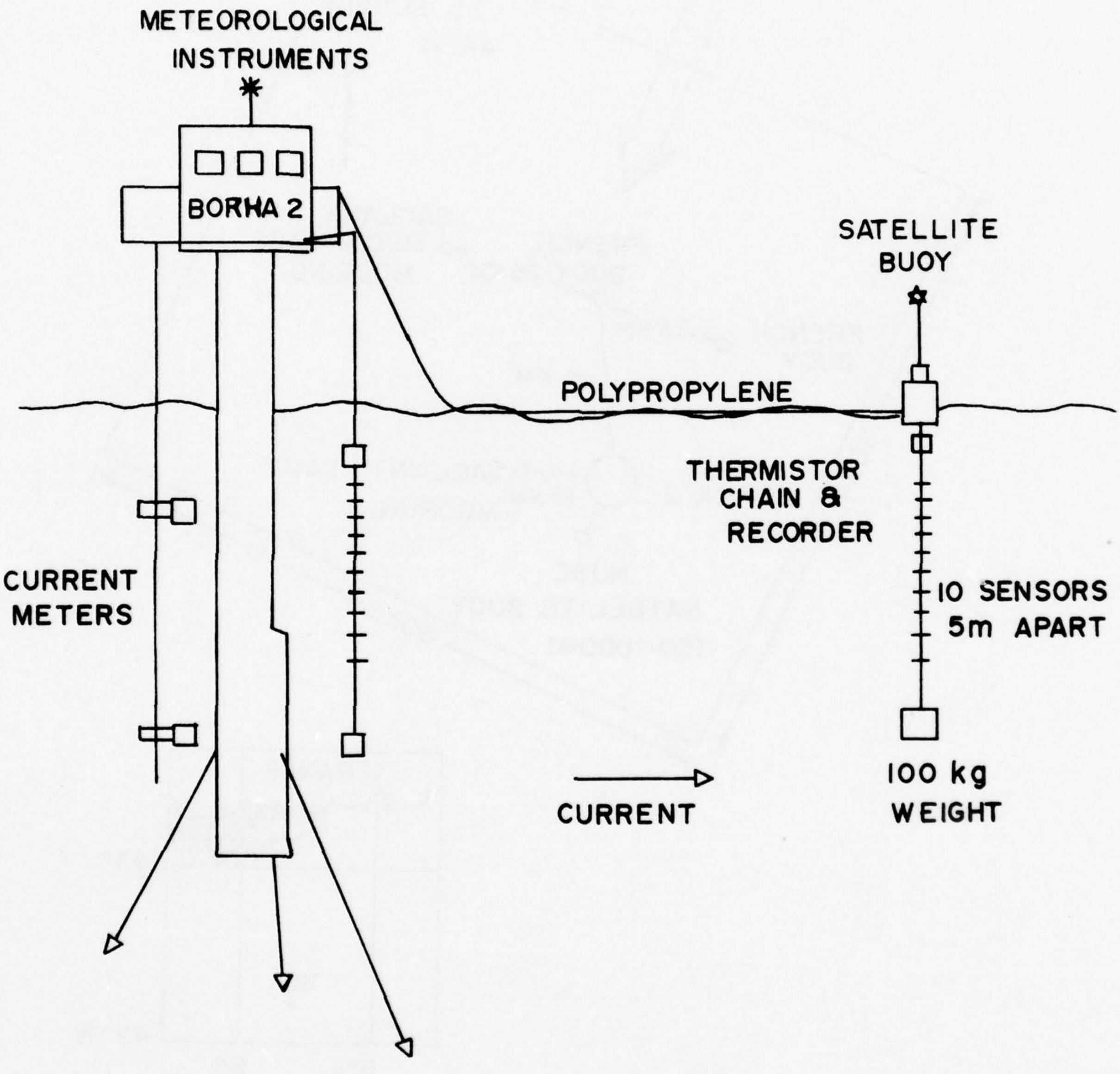


FIGURE 2. NUSC TETHERED BUOY EXPERIMENT

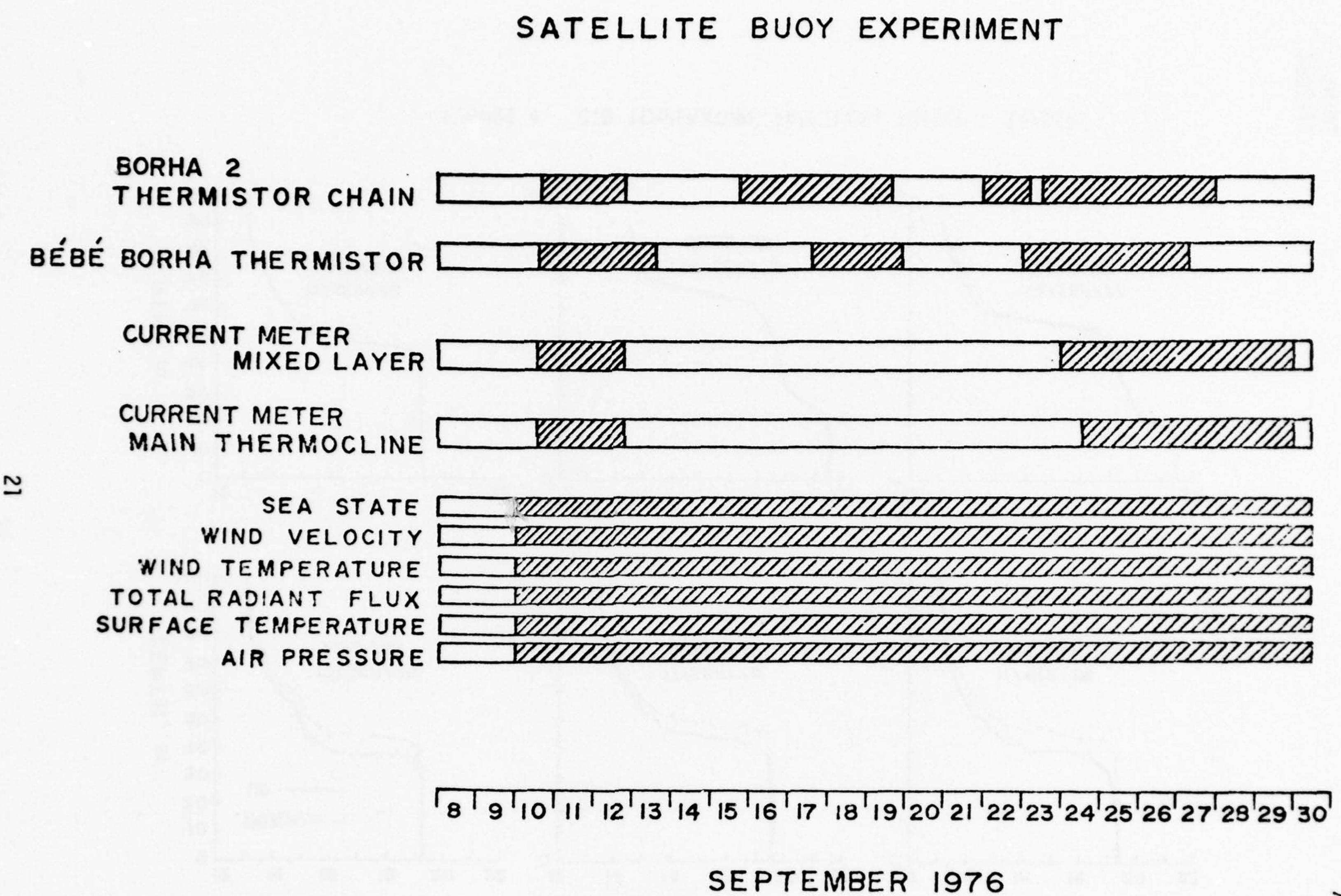


FIGURE 3. DATA COLLECTED DURING COBLAMED '76

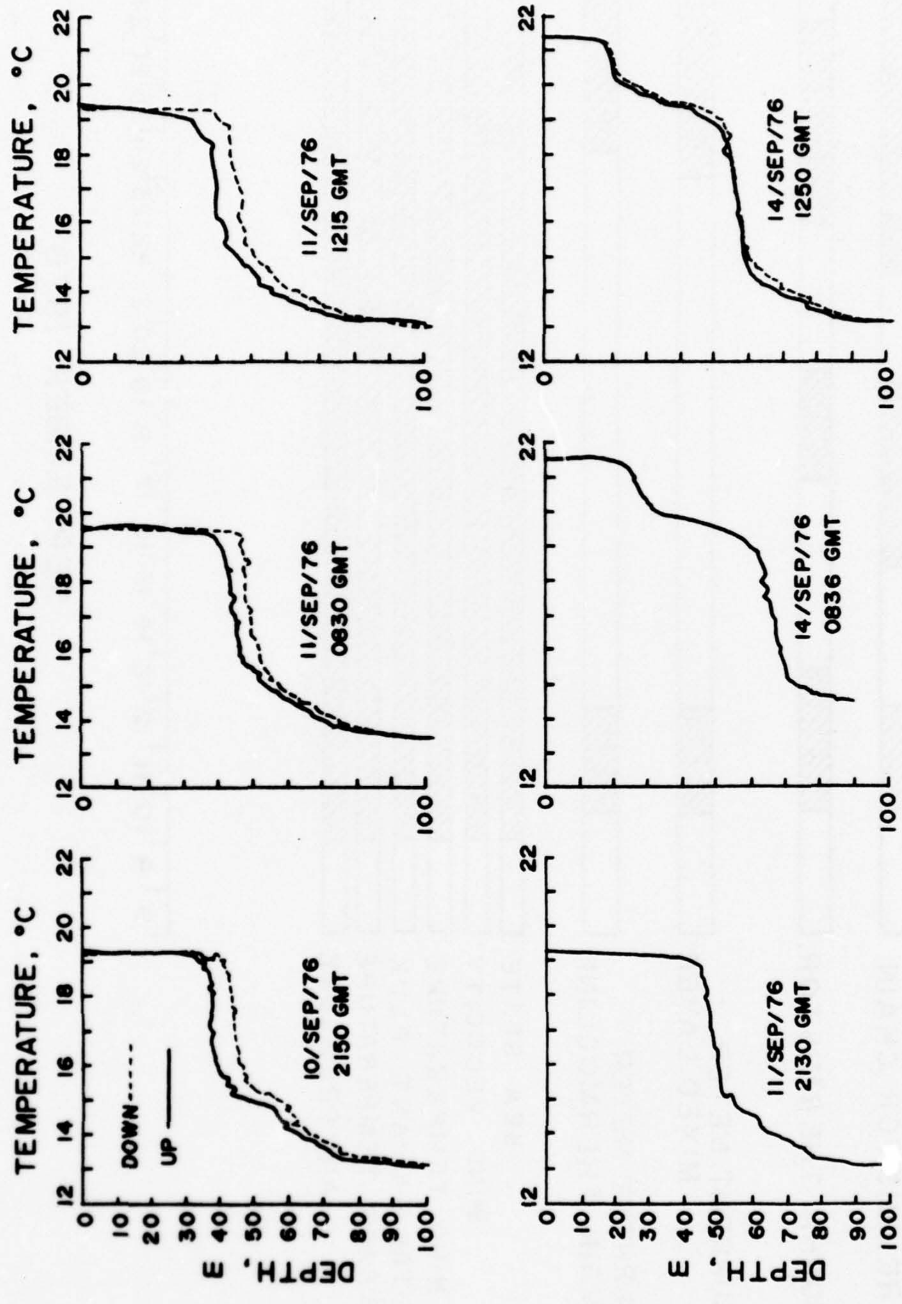


FIGURE 4. CTD TEMPERATURE PROFILES, 10/SEP - 14/SEP

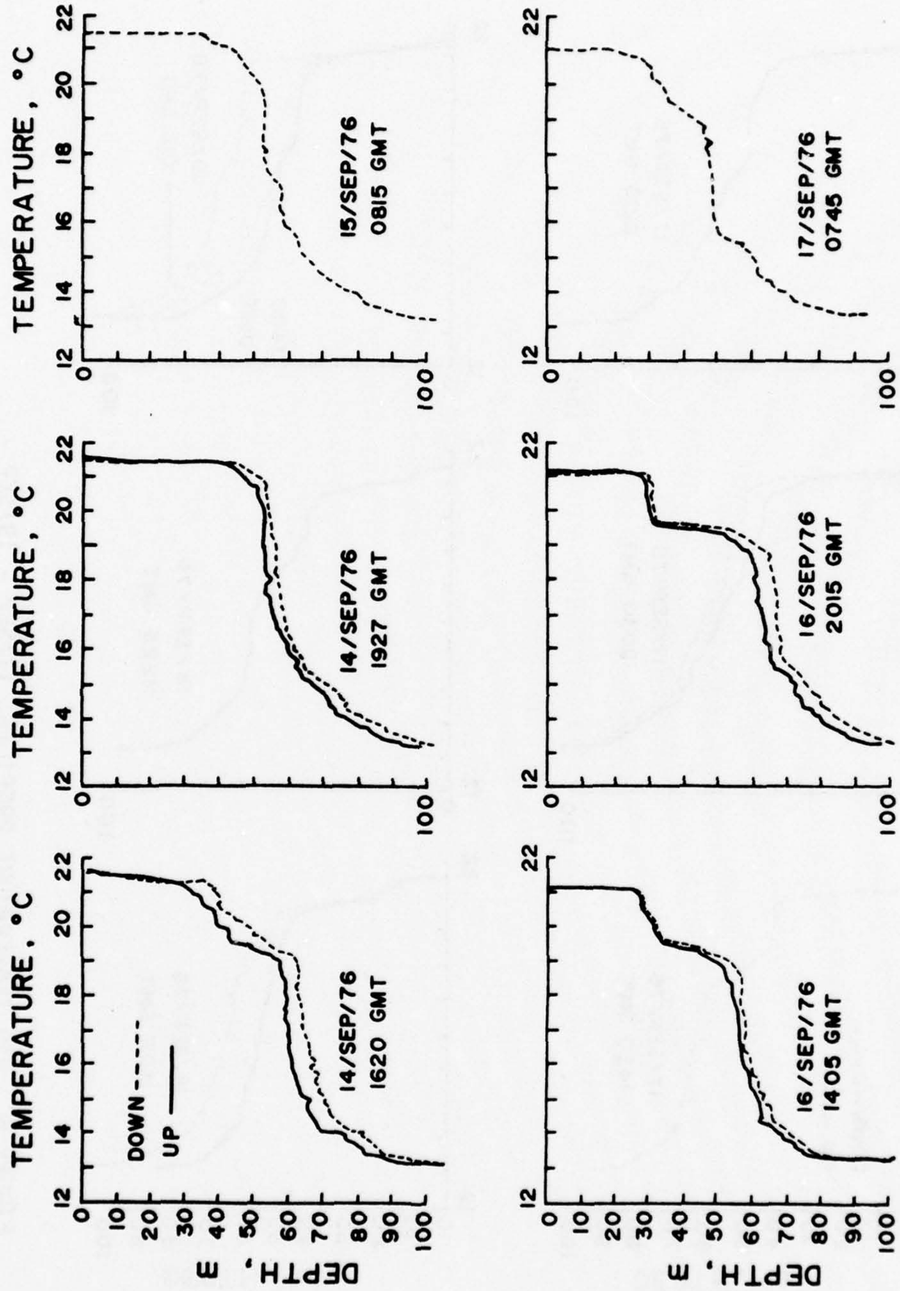


FIGURE 5. CTD TEMPERATURE PROFILES, 14/SEP - 17/SEP

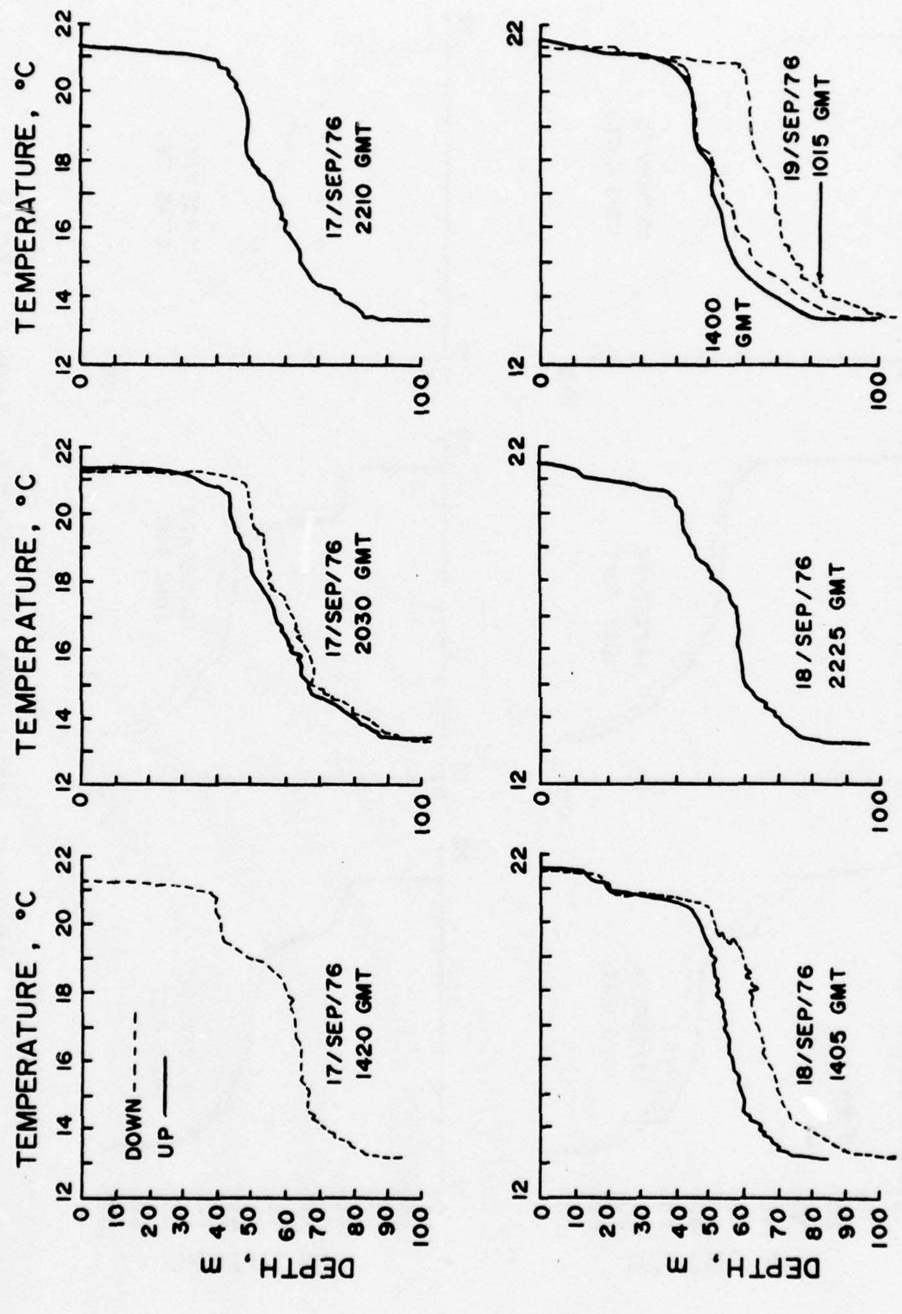


FIGURE 6. CTD TEMPERATURE PROFILES, 17/SEP - 19/SEP

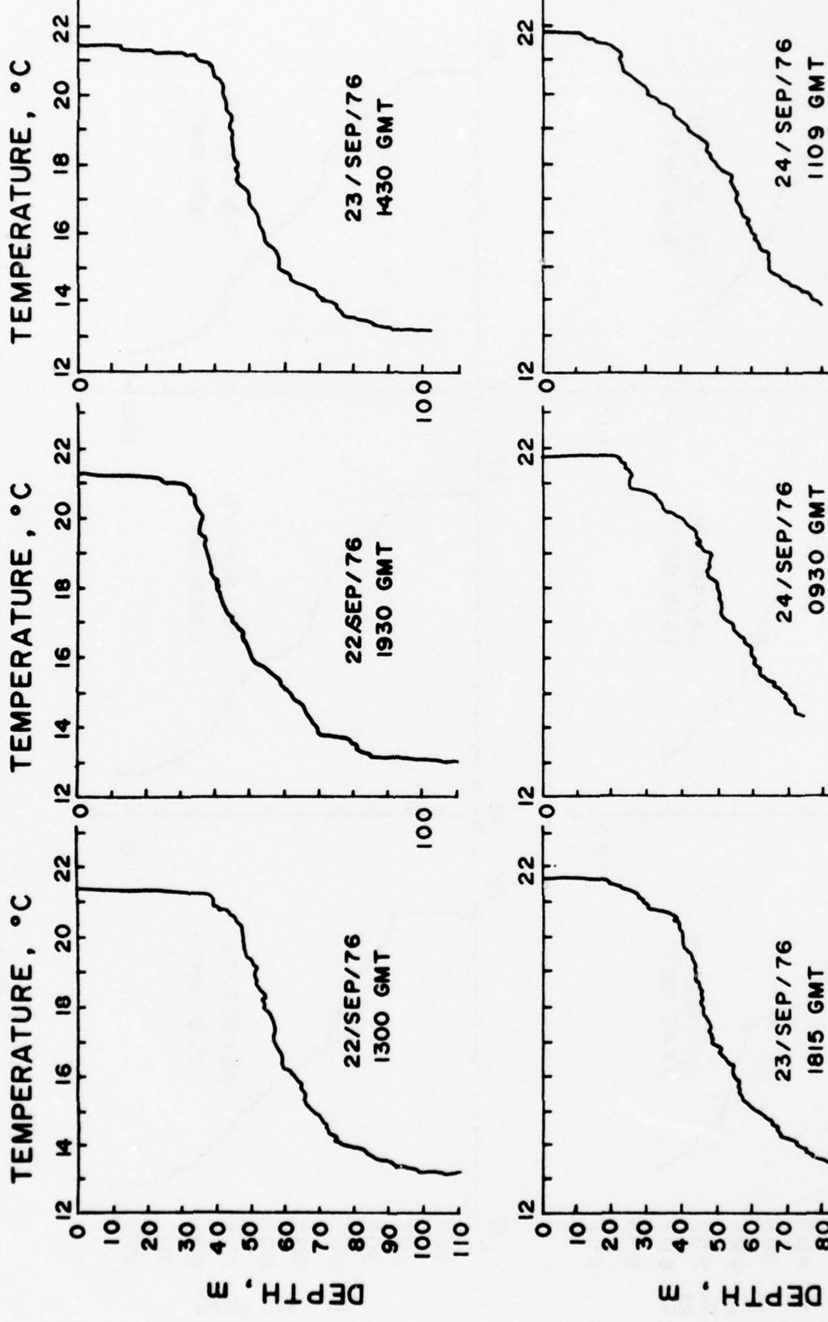


FIGURE 7. CTD TEMPERATURE PROFILES, 22/SEP - 24/SEP

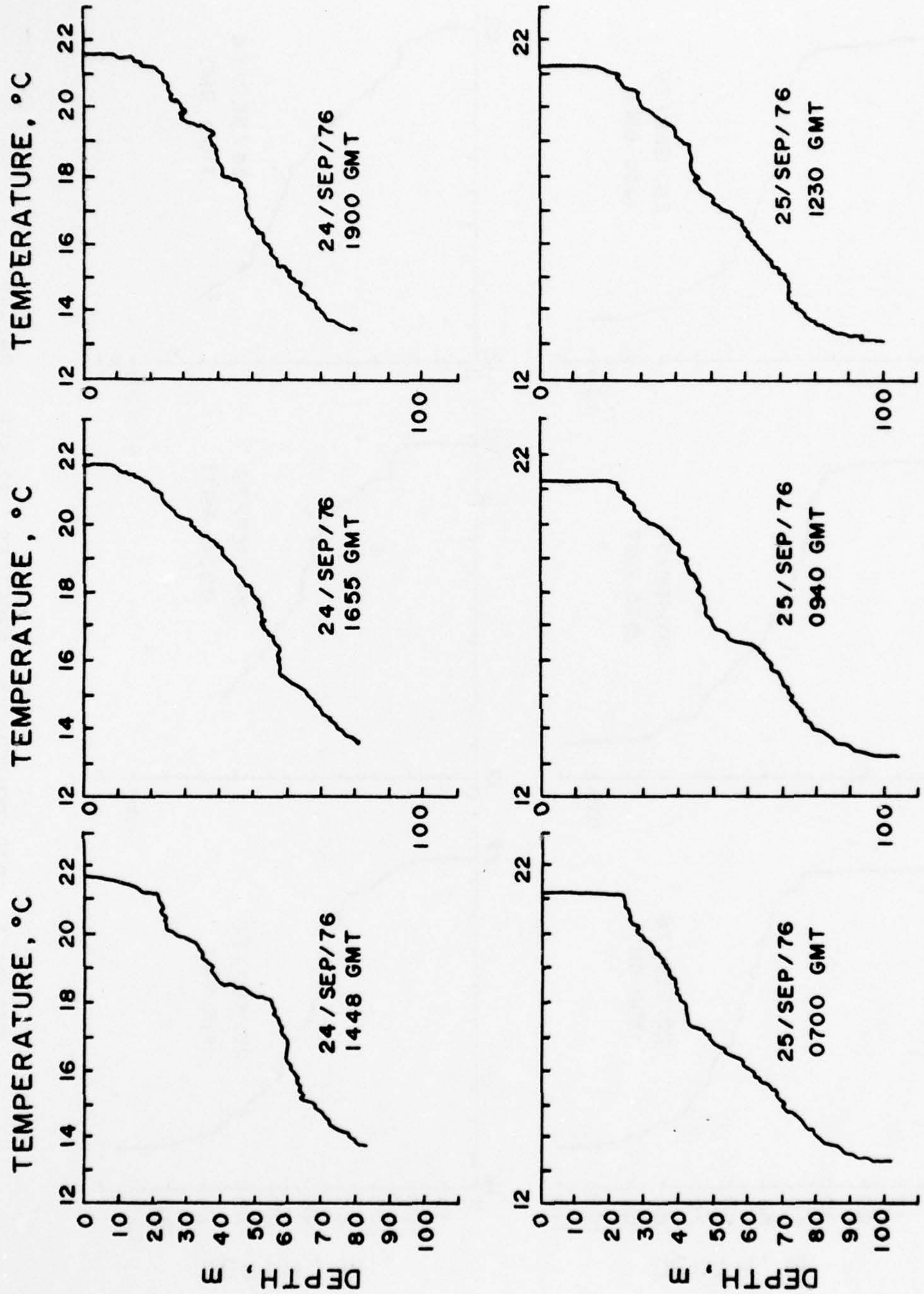


FIGURE 8. CTD TEMPERATURE PROFILES, 24/SEP - 25/SEP

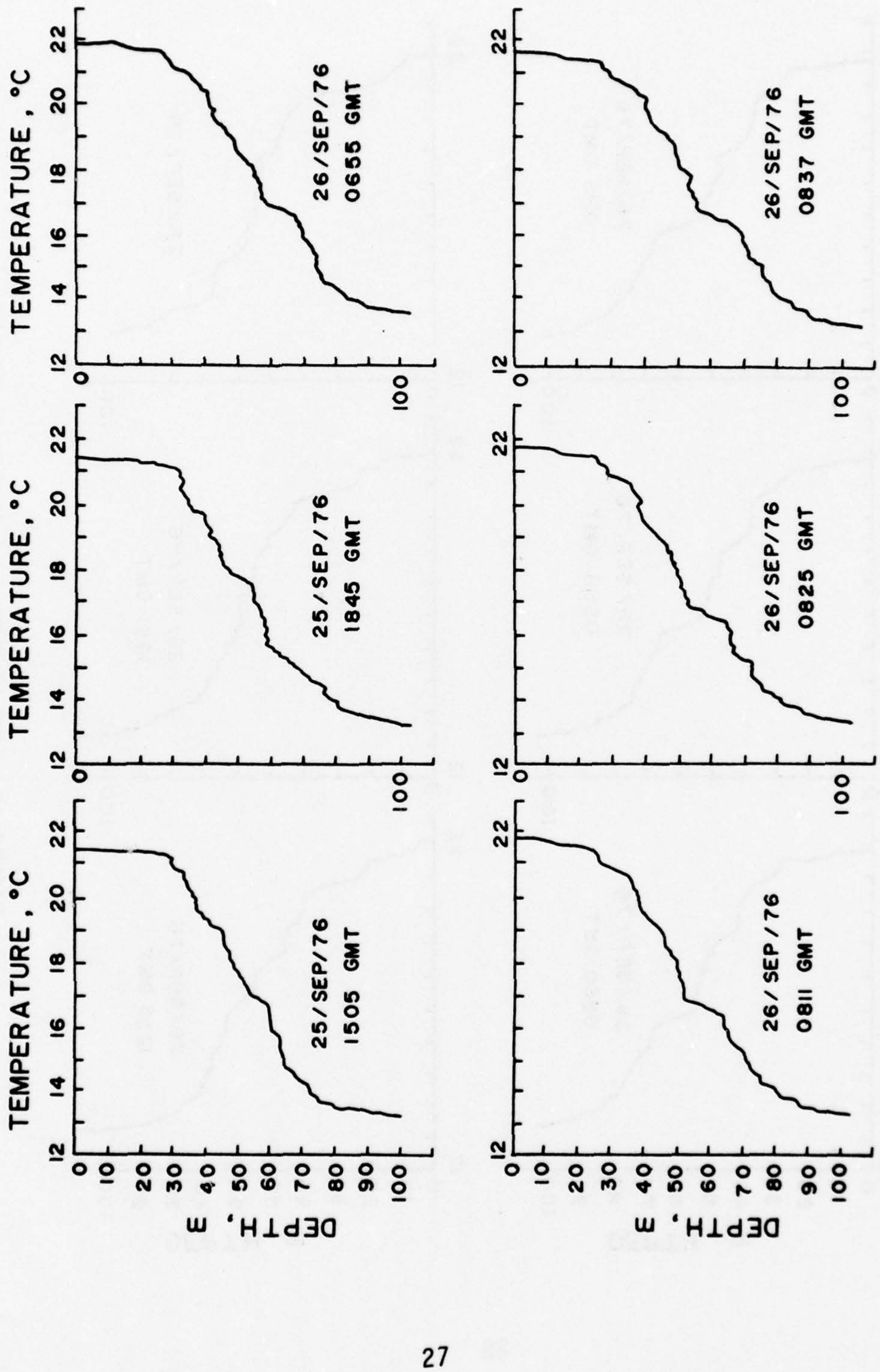


FIGURE 9. CTD TEMPERATURE PROFILES, 25/SEP - 26/SEP

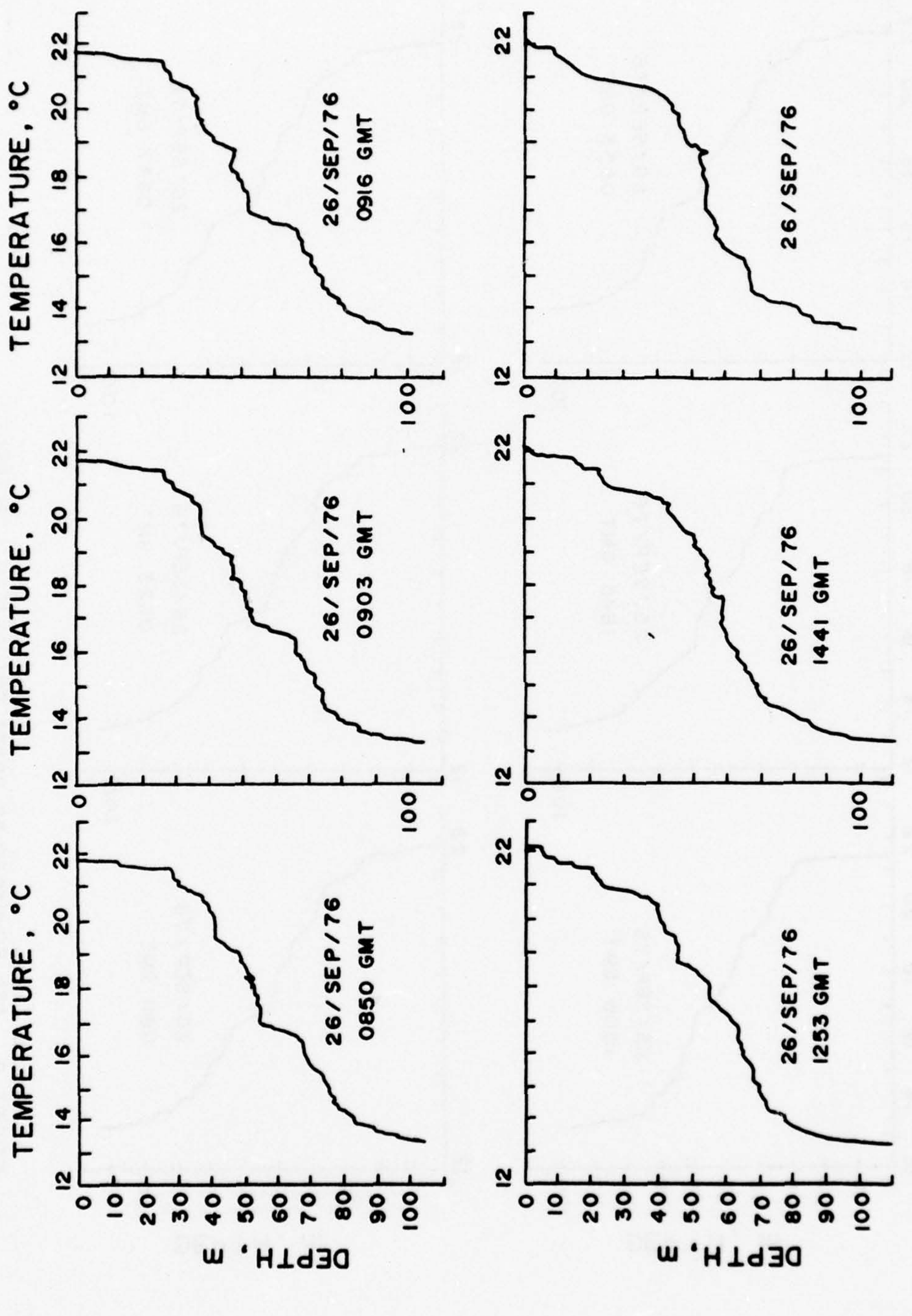


FIGURE 10. CTD TEMPERATURE PROFILES, 26/SEP

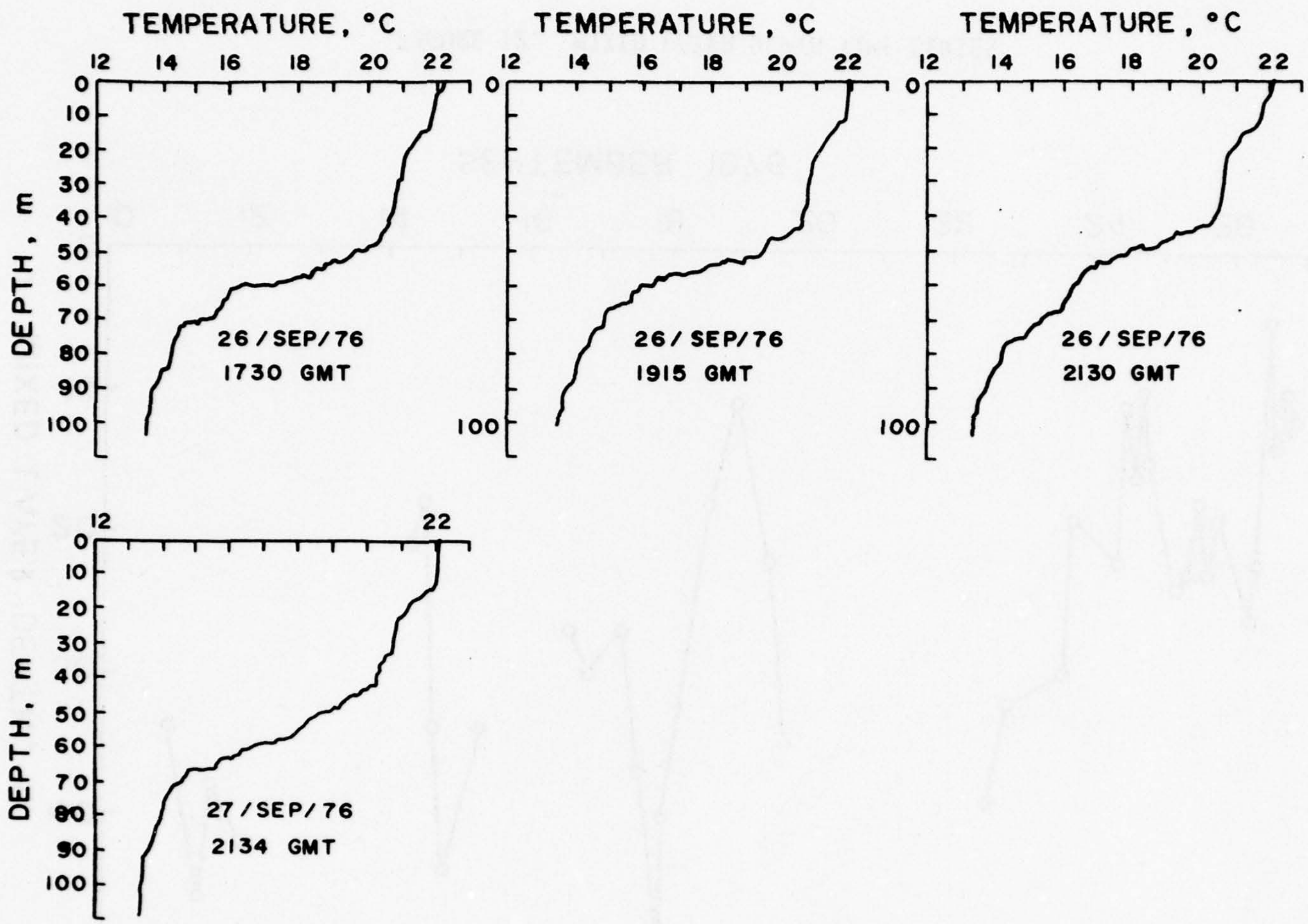


FIGURE 11. CTD TEMPERATURE PROFILES, 26/SEP - 27/SEP

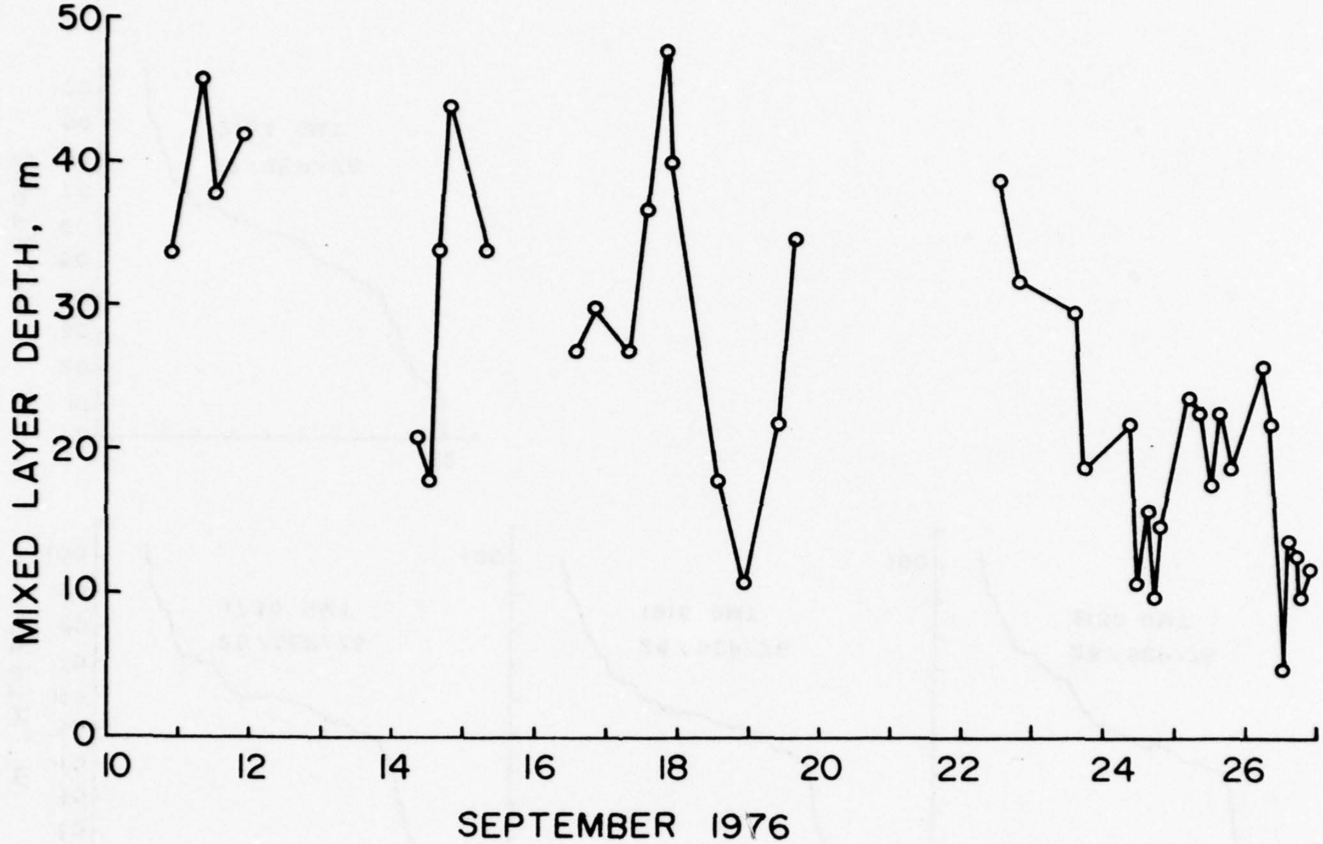


FIGURE 12. MIXED LAYER DEPTH TIME SERIES

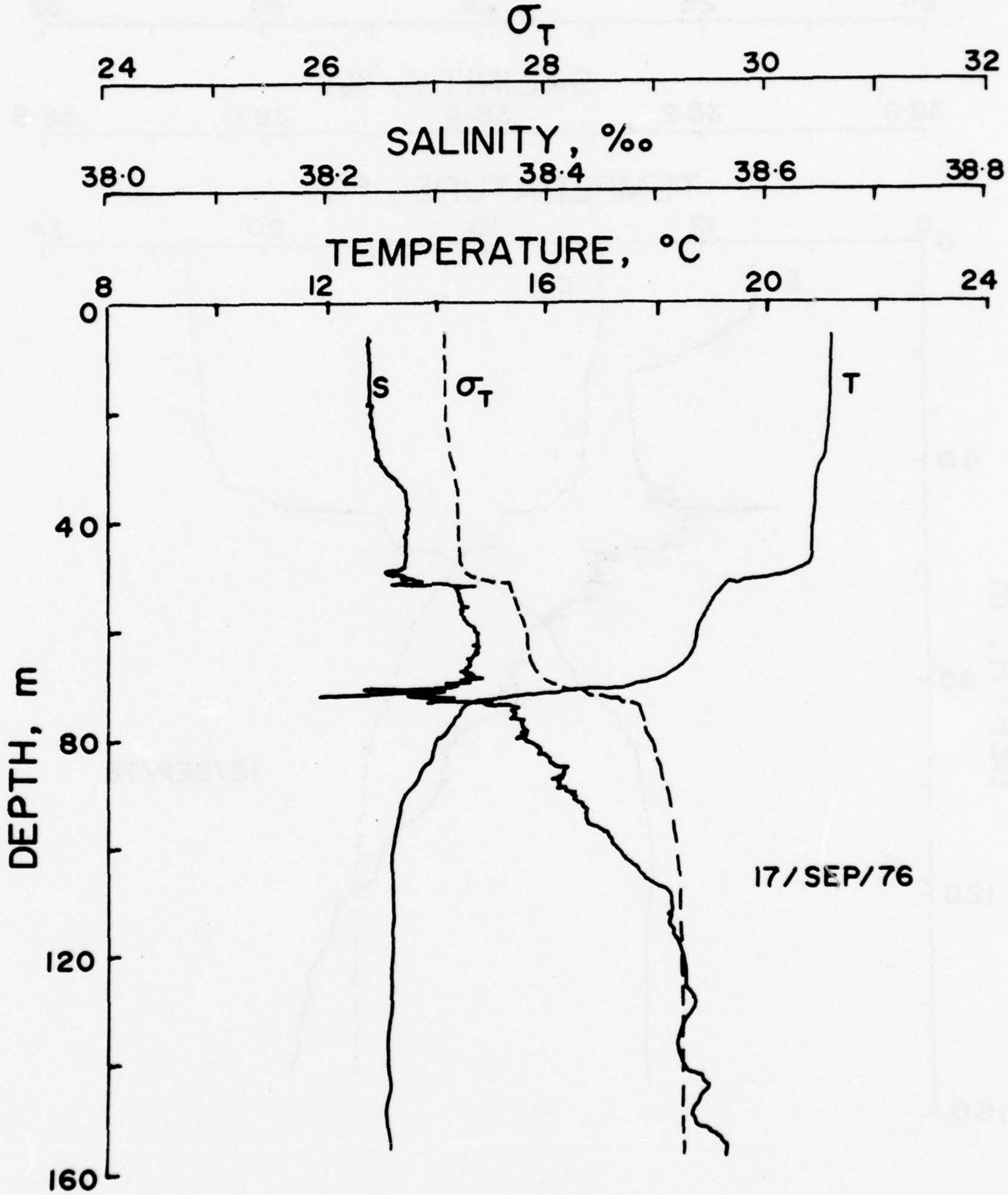


FIGURE 13. CTD PROFILE FROM THE MAGNAGHI, 2010 (A+1)/17/SEP/76

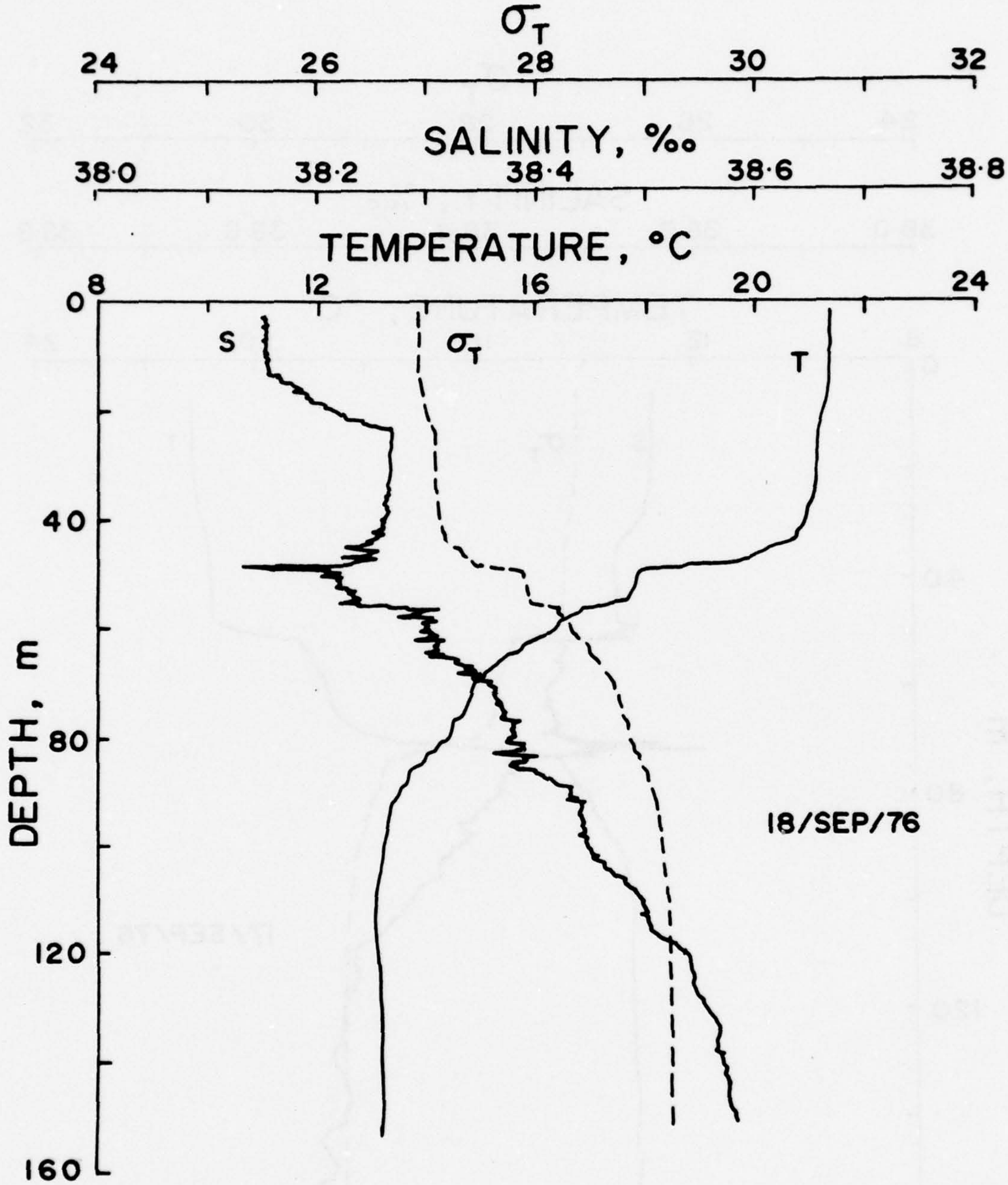


FIGURE 14. CTD PROFILE FROM THE MAGNAGHI, 0920(A+1)/18/SEP/76

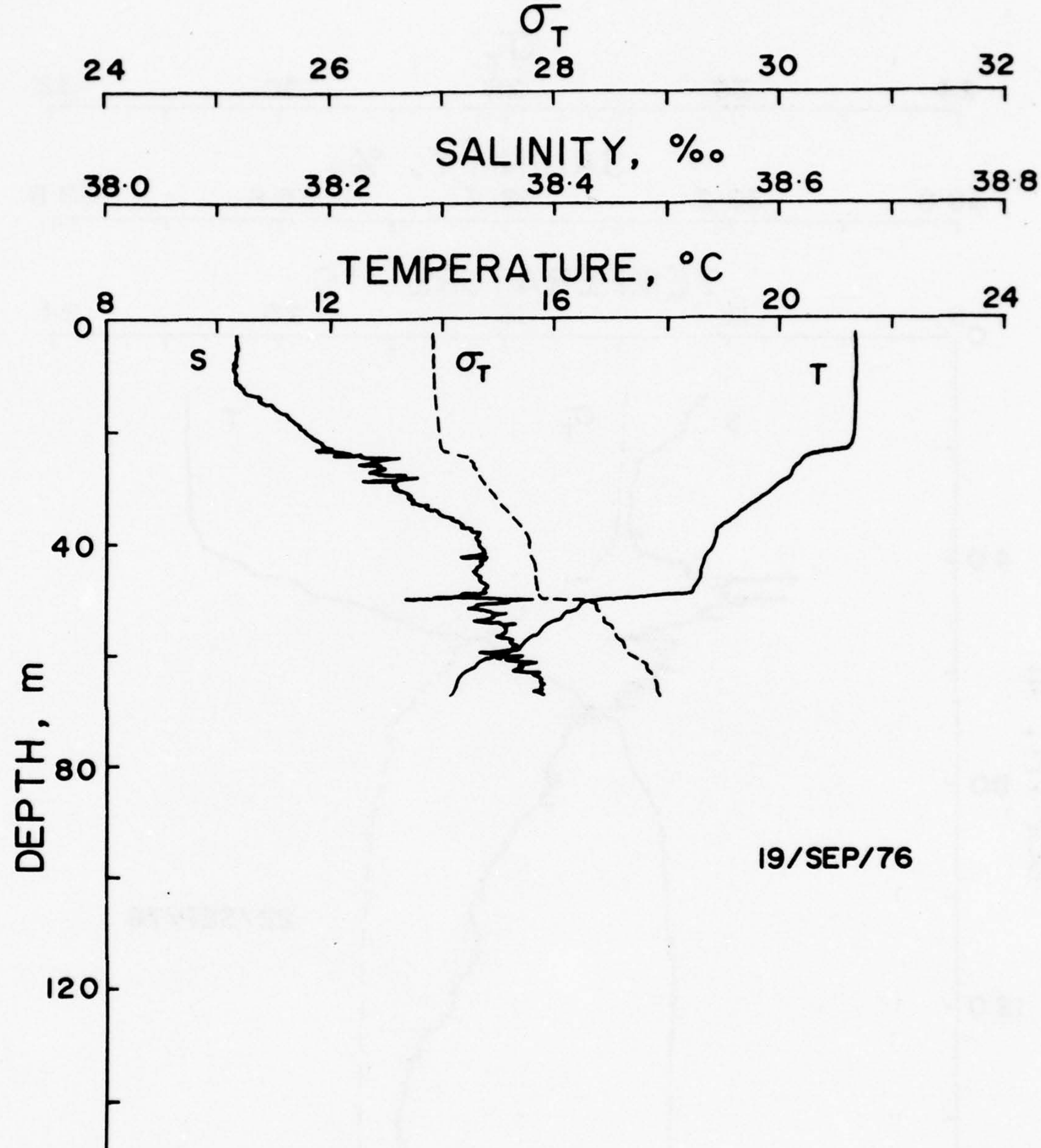


FIGURE 15. CTD PROFILE FROM THE MAGNAGHI, 1300(A+1)/19/SEP/76

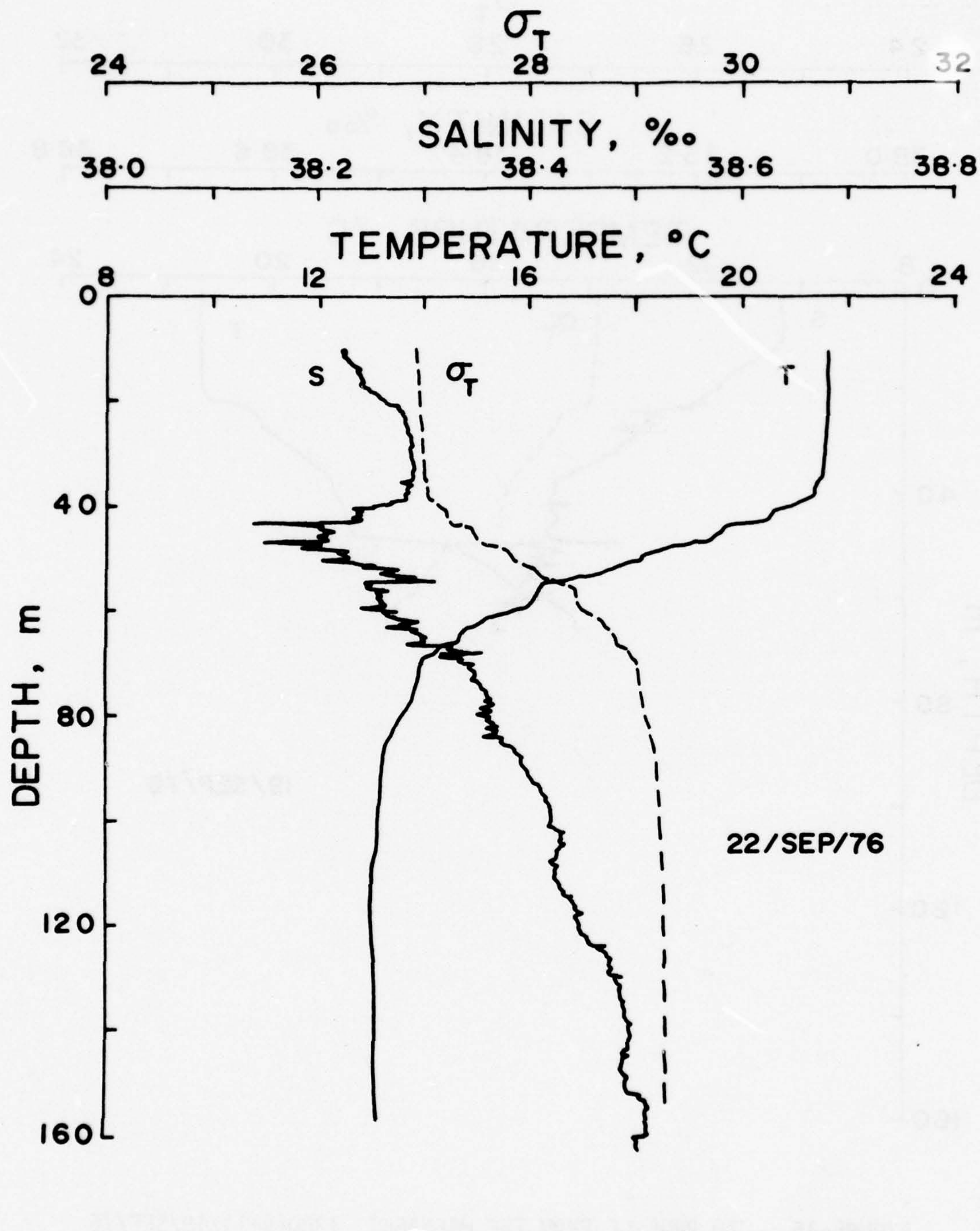


FIGURE 16. CTD PROFILE FROM THE MAGNAGHI, 1350(A+1)/22/SEP/76

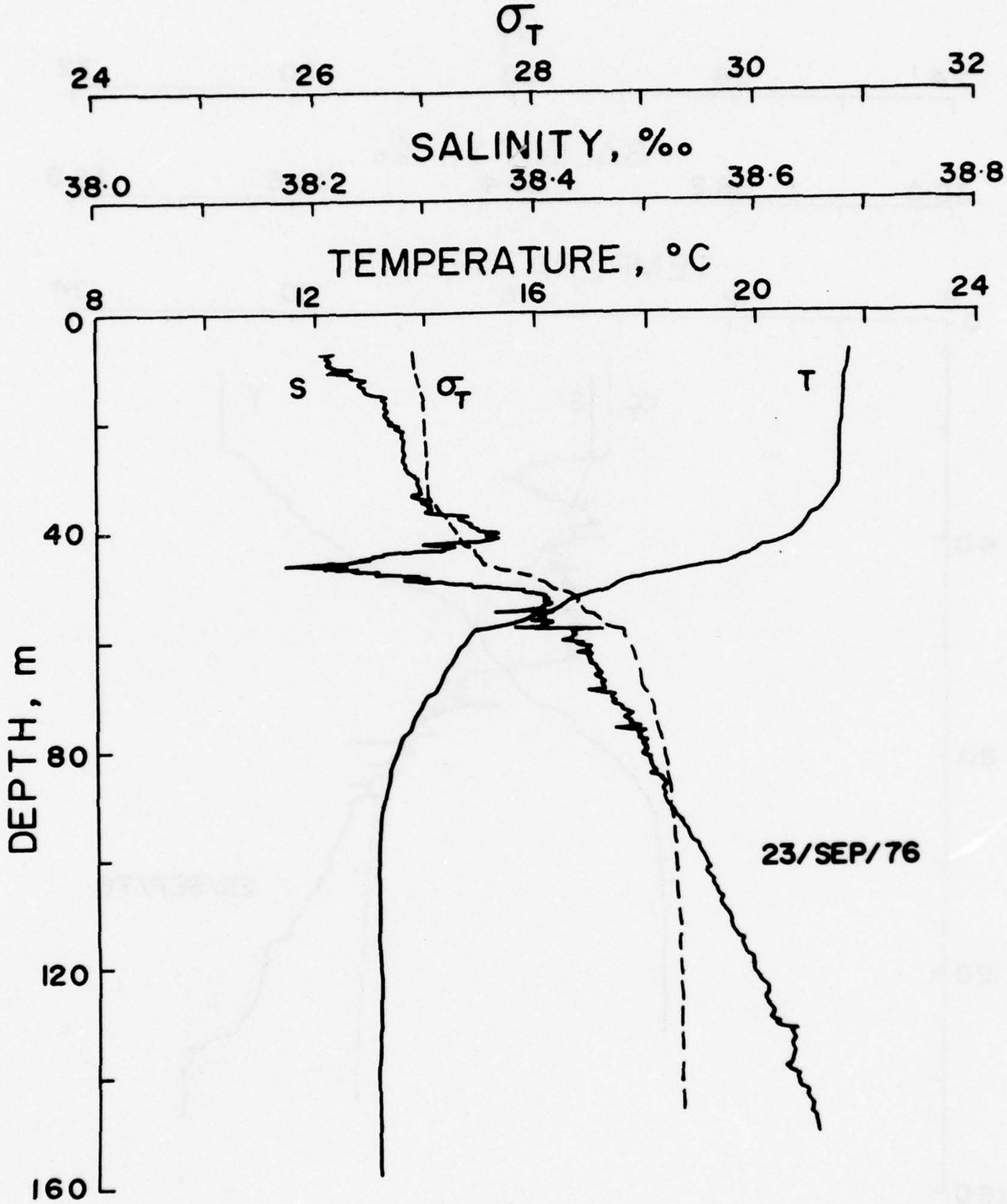


FIGURE 17. CTD PROFILE FROM THE MAGNAGHI, 1850(A+1)/23/SEP/76

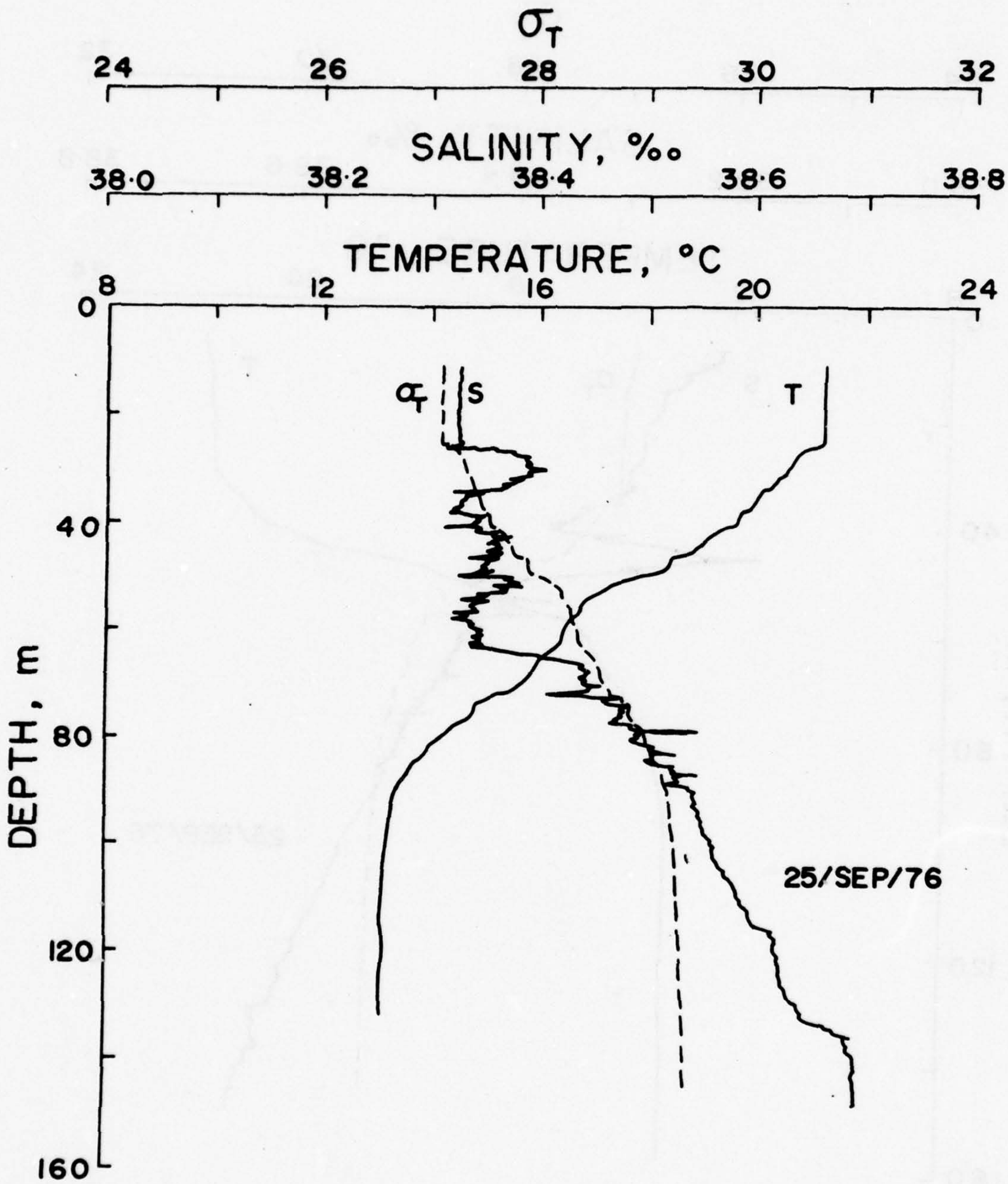


FIGURE 18. CTD PROFILE FROM THE MAGNAGHI, 0925(A+1)/25/SEP/76

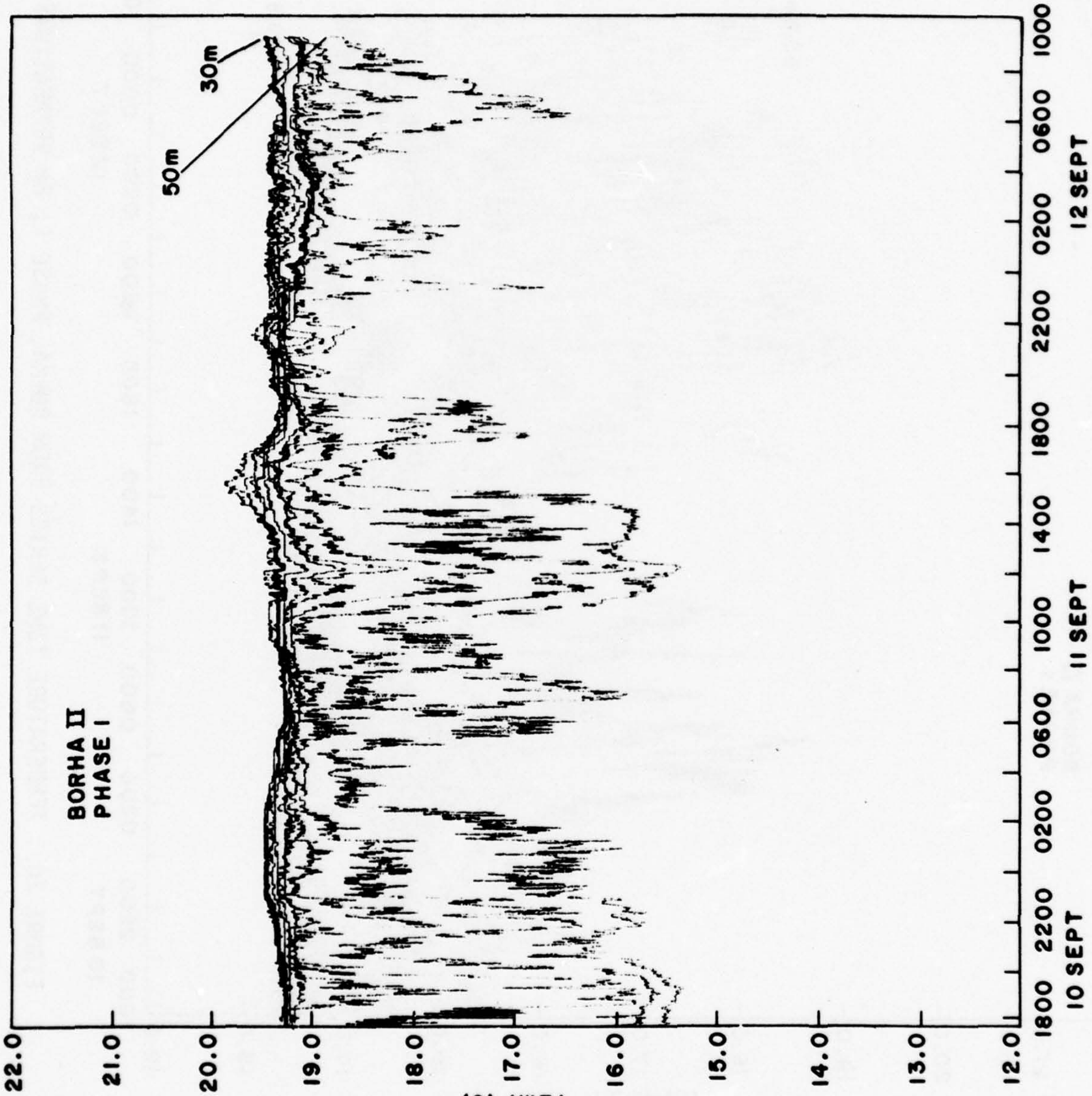


FIGURE 19. TEMPERATURE TIME SERIES FROM BORHA, PHASE I, 2m SEPARATIONS.

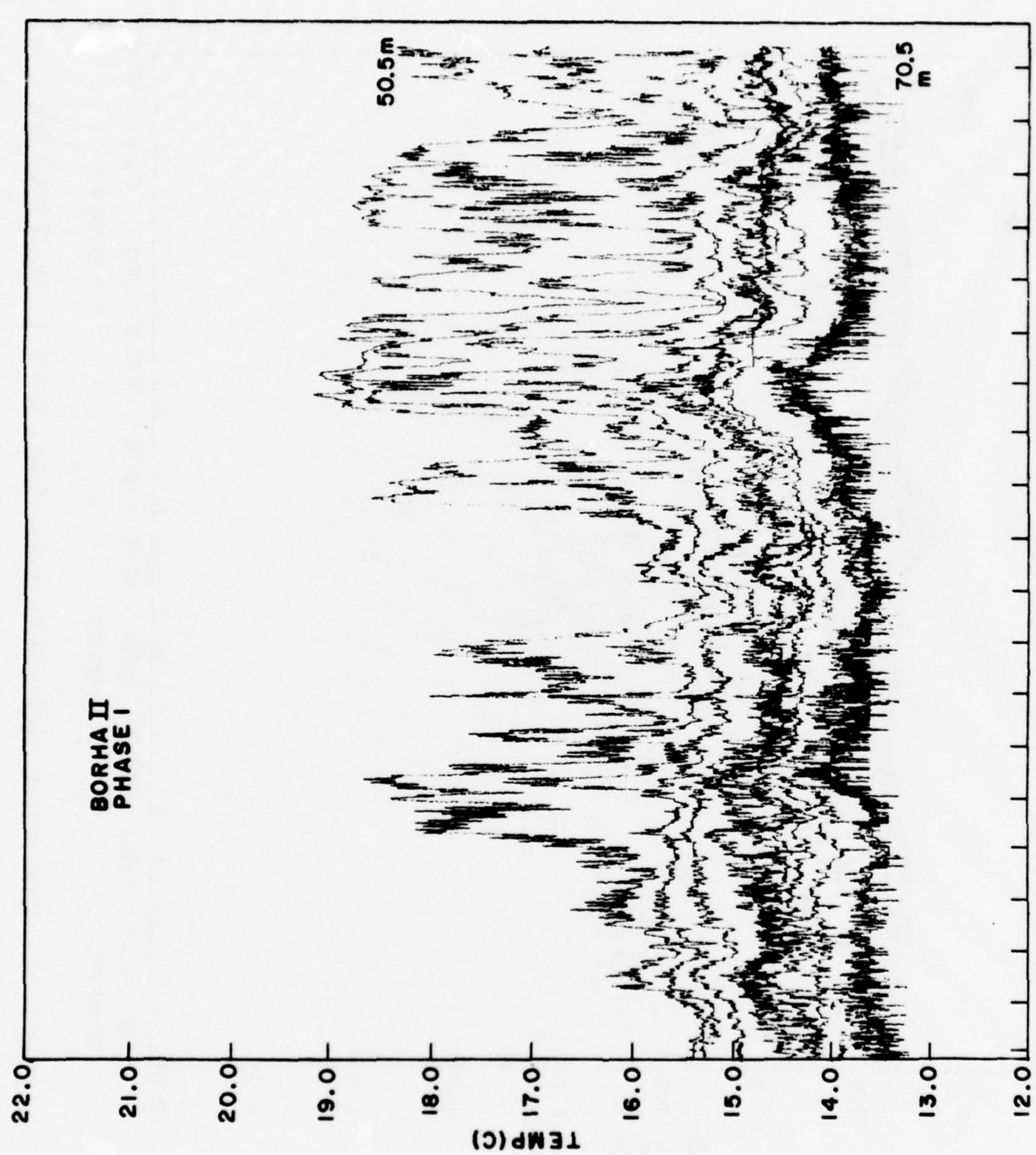


FIGURE 20. TEMPERATURE TIME SERIES FROM BORHA, PHASE I, 2m SEPARATIONS.

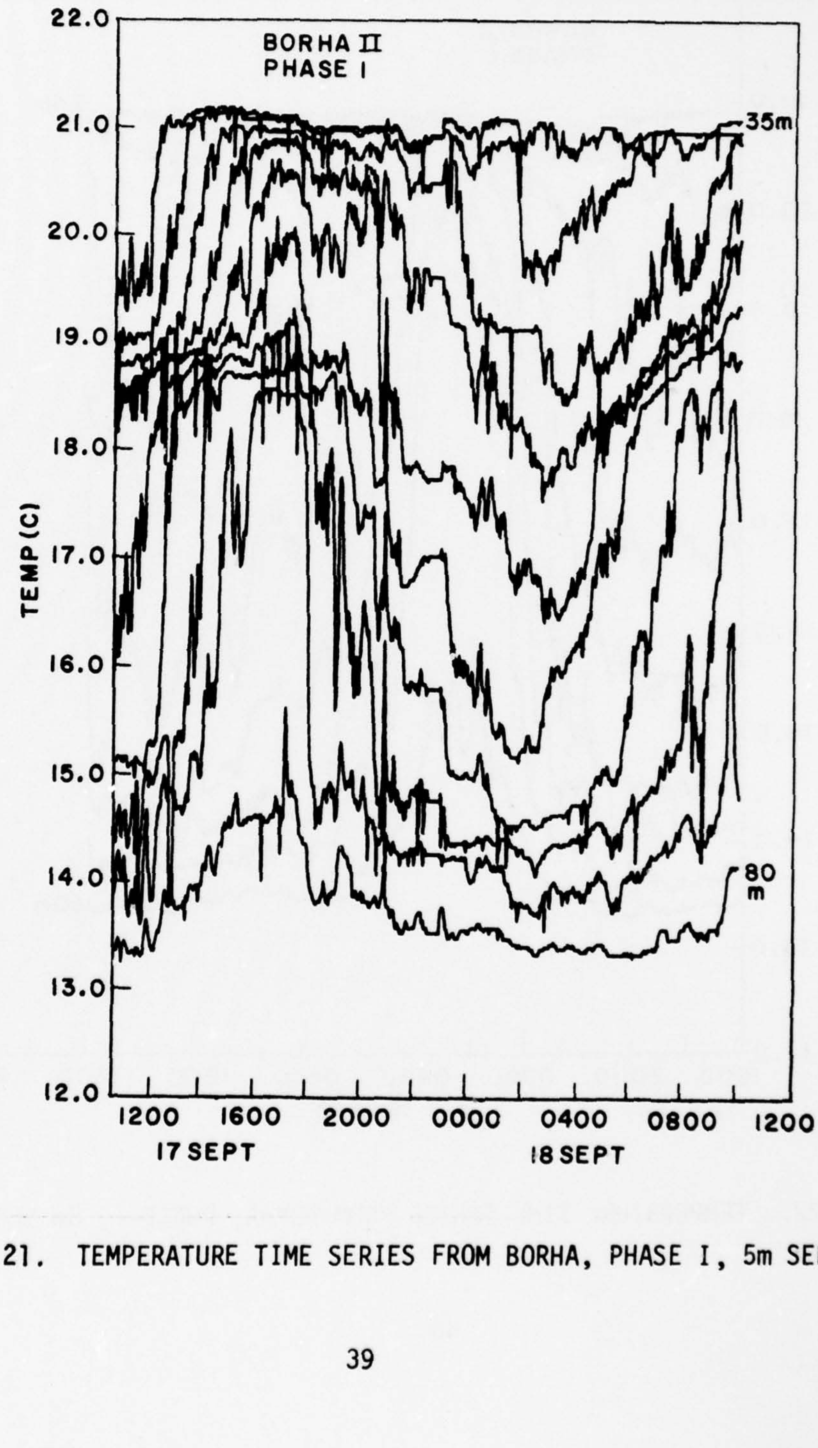


FIGURE 21. TEMPERATURE TIME SERIES FROM BORHA, PHASE I, 5m SEPARATIONS.

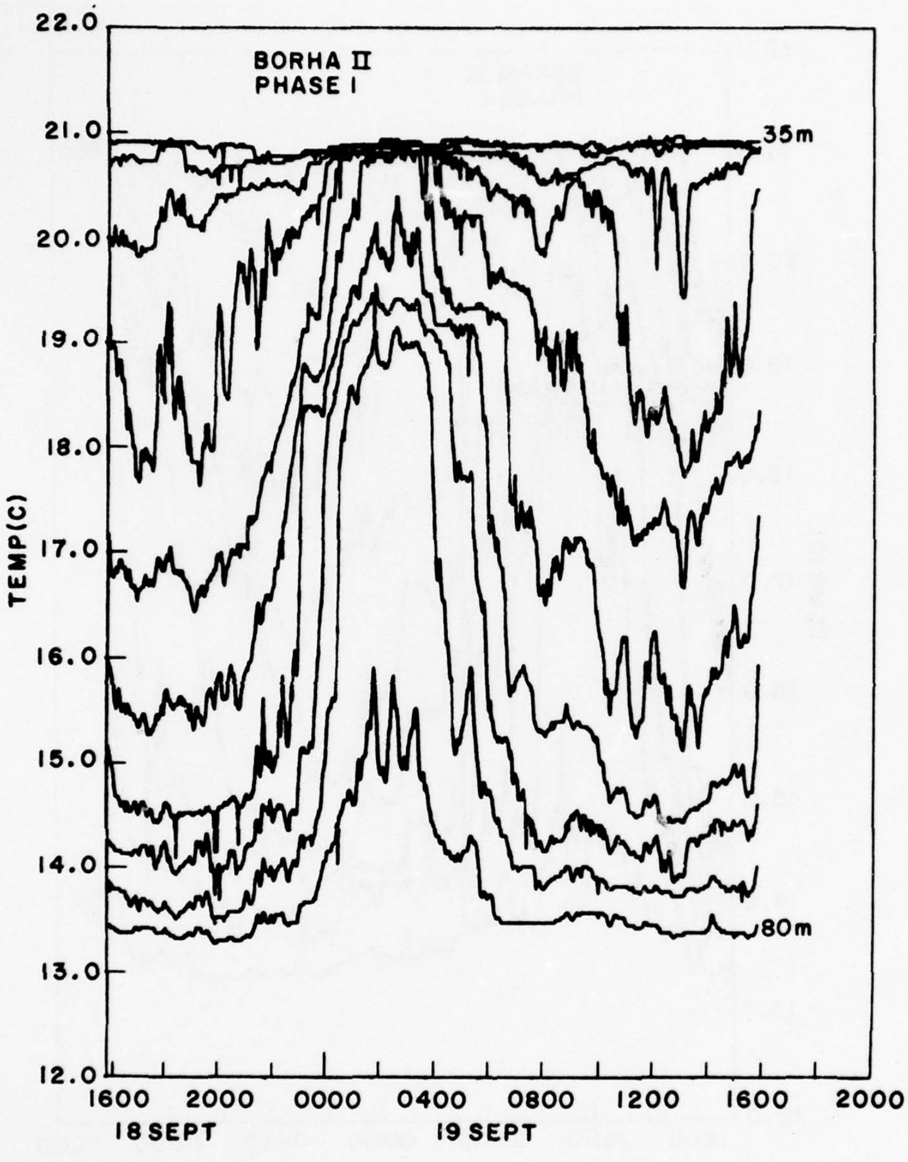
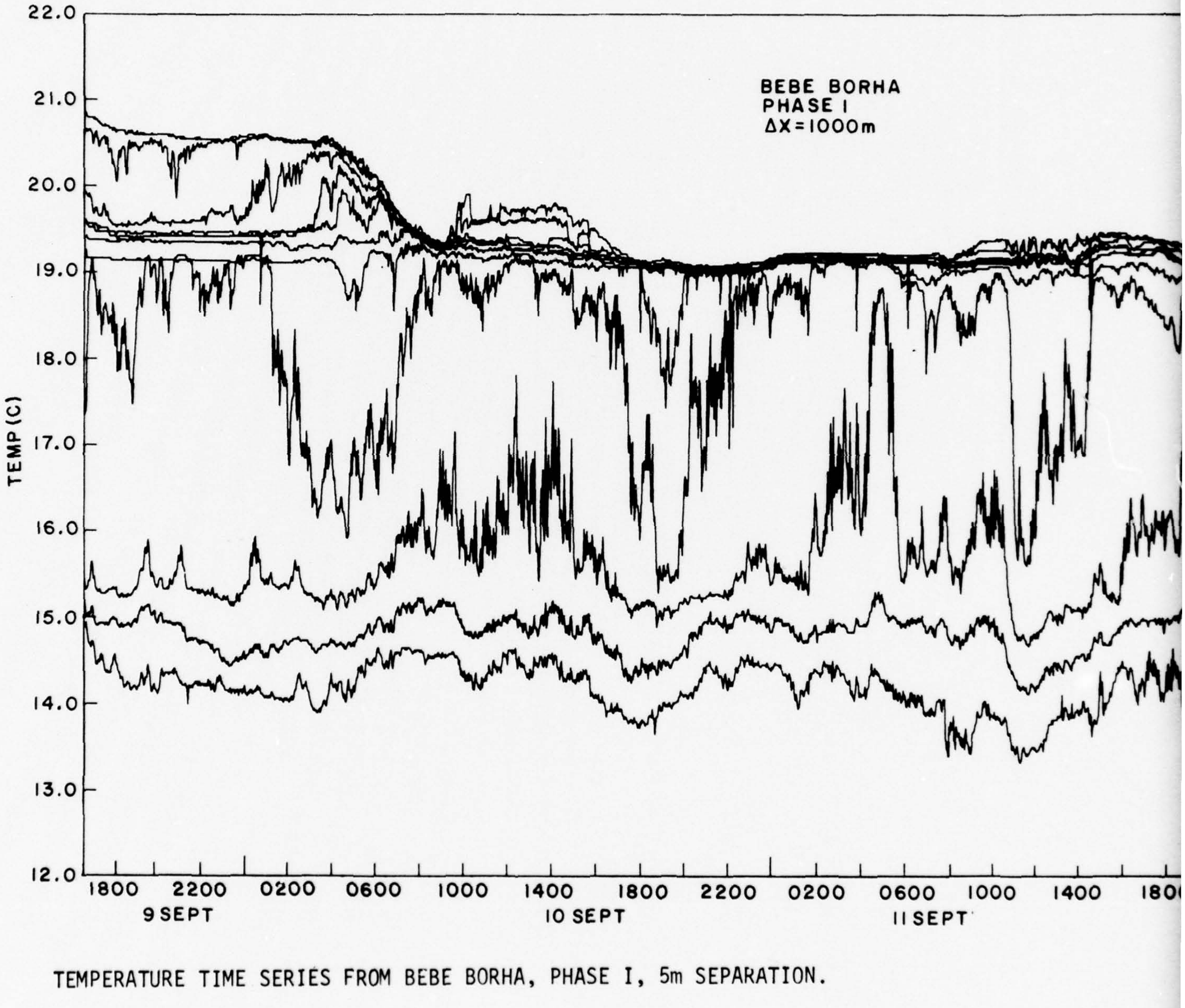


FIGURE 22. TEMPERATURE TIME SERIES FROM BORHA, PHASE I, 5m SEPARATIONS.



TEMPERATURE TIME SERIES FROM BEBE BORHA, PHASE I, 5m SEPARATION.

2

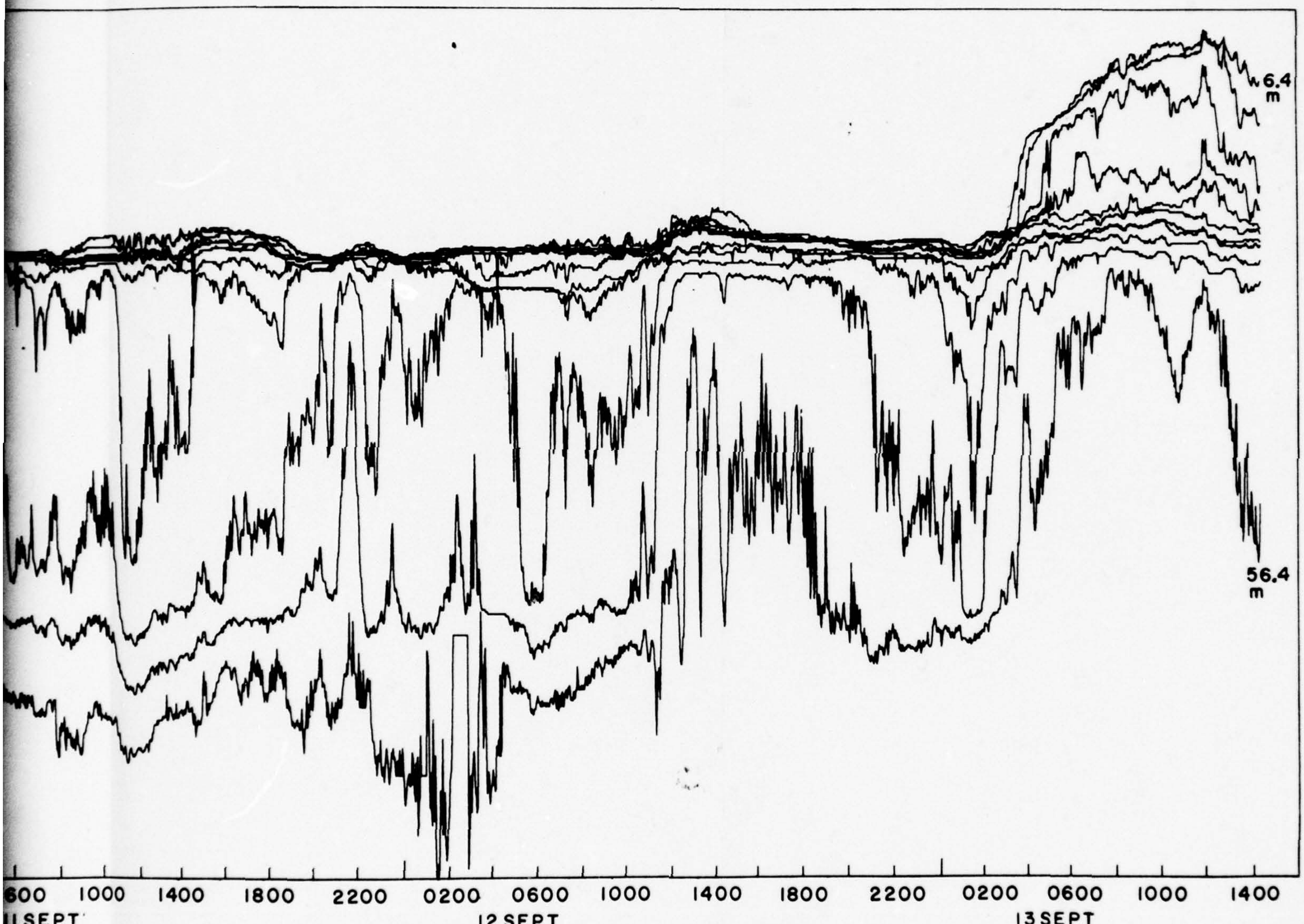

6.4
m
56.4
m
600
1000
1400
1800
2200
0200
0600
1000
1400
1800
2200
0200
0600
1000
1400
11 SEPT
12 SEPT
13 SEPT

FIGURE 23

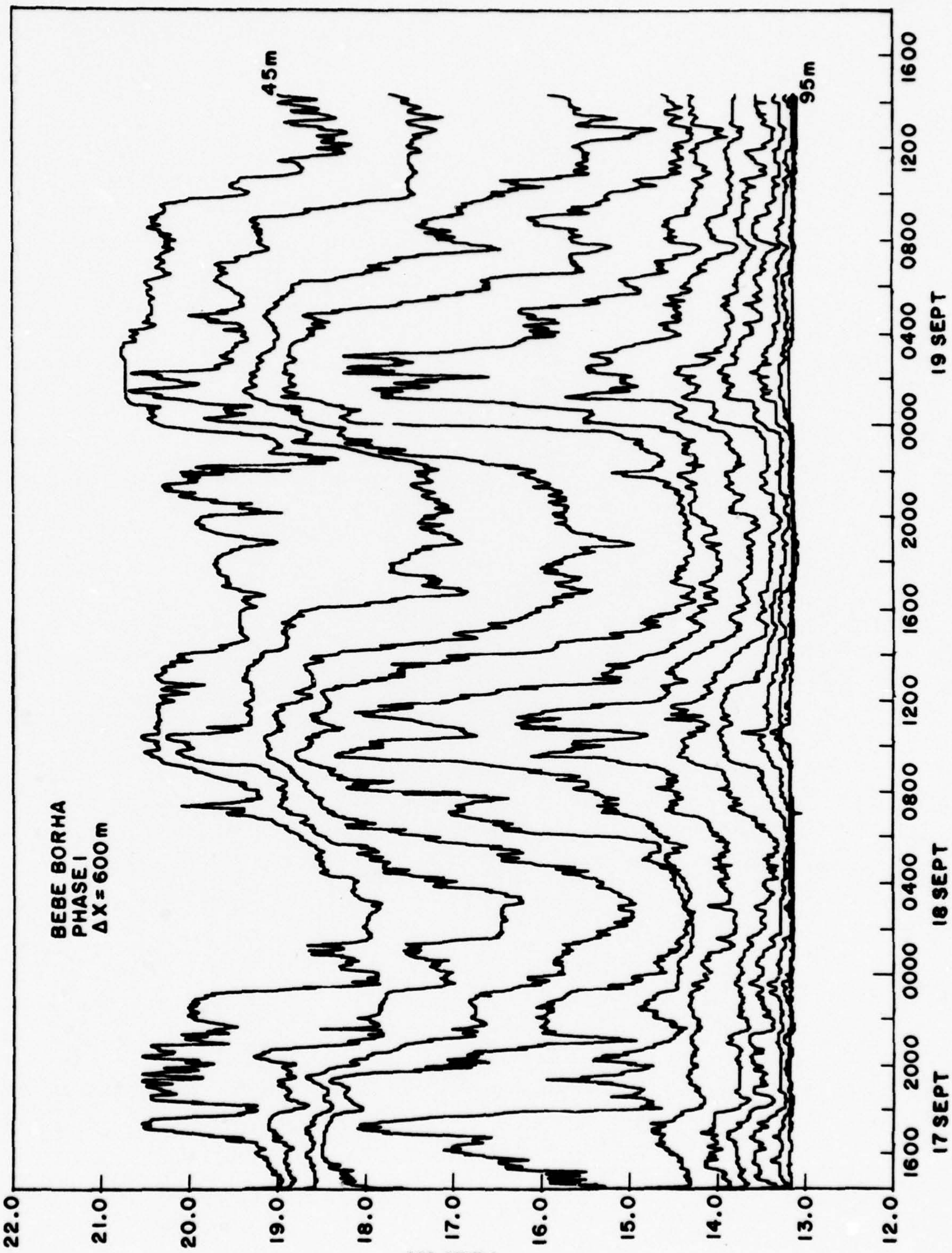
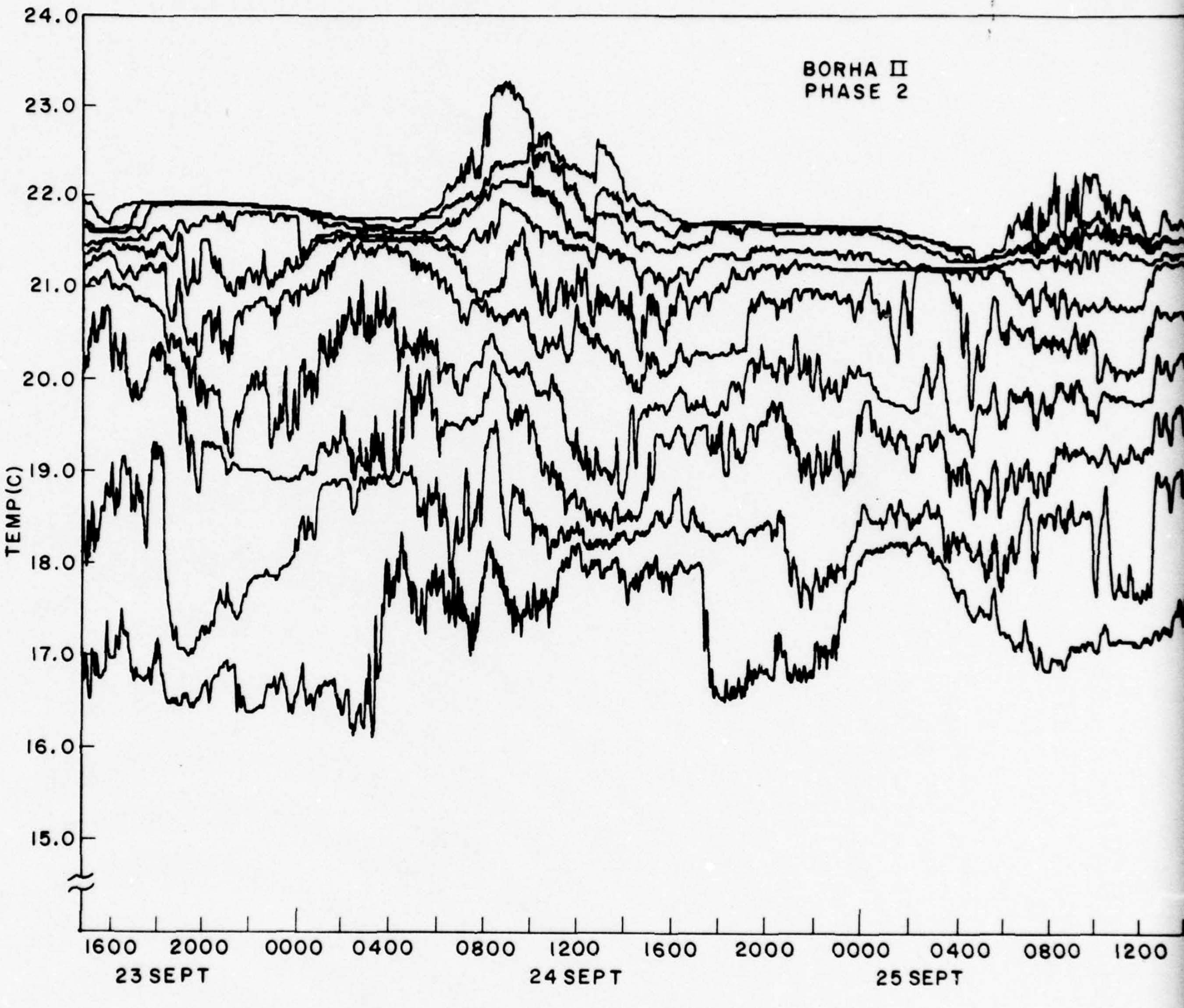


FIGURE 24. TEMPERATURE TIME SERIES FROM BEBE BORHA, PHASE I, 5m SEPARATIONS.



TEMPERATURE TIME SERIES FROM BORHA II, PHASE II, 5m SEPARATIONS.

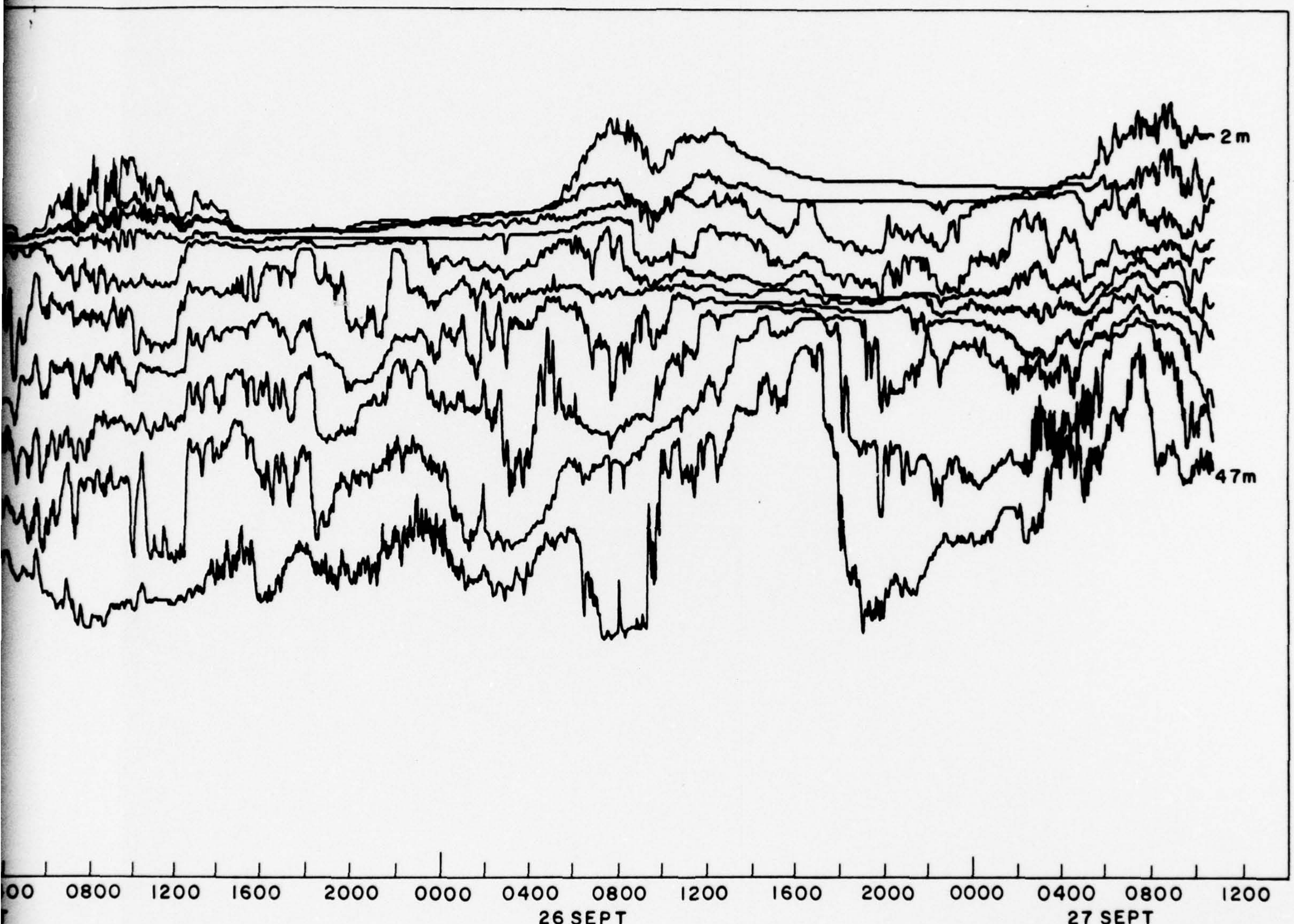

2m
47m
00 0800 1200 1600 2000 0000 0400 0800 1200 1600 2000 0000 0400 0800 1200
26 SEPT
27 SEPT

FIGURE 25

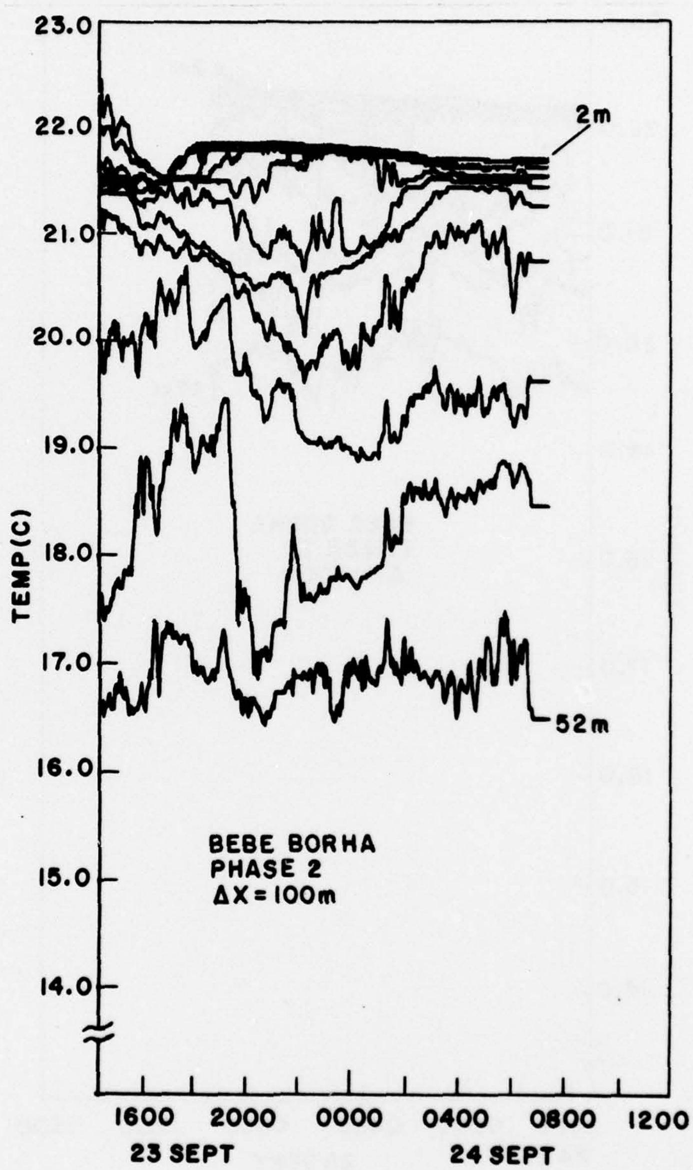


FIGURE 26. TEMPERATURE TIME SERIES FROM BEBE BORHA, PHASE II, 5m SEPARATIONS.

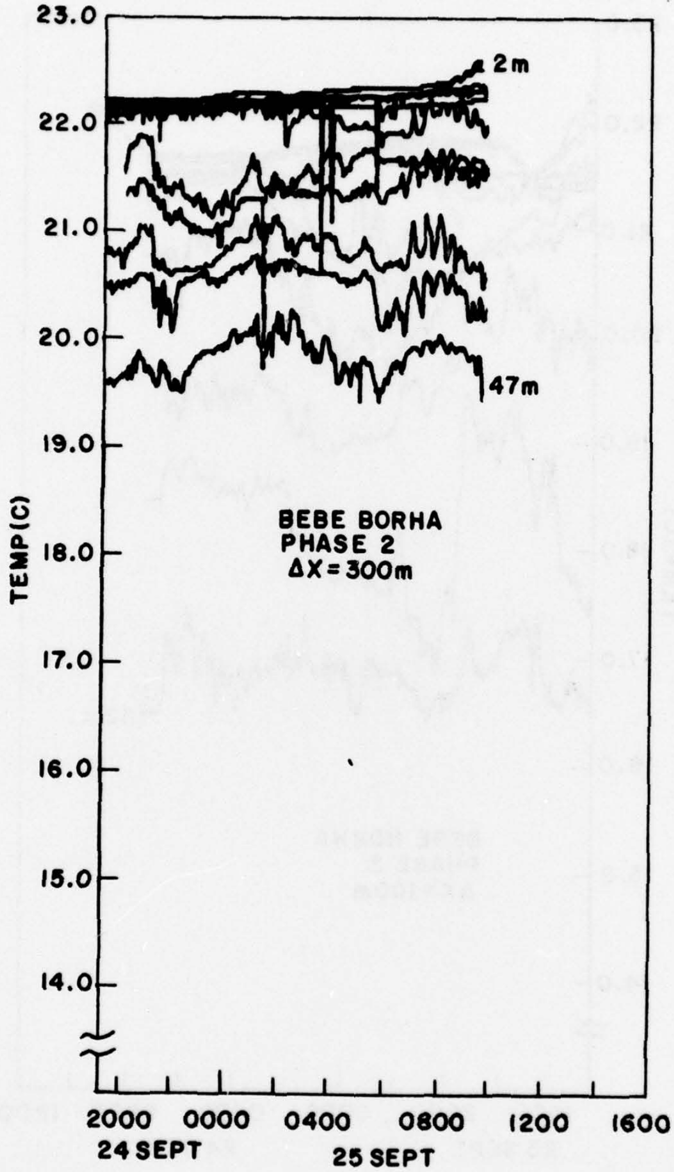


FIGURE 27. TEMPERATURE TIME SERIES FROM BEBE BORHA, PHASE II, 5m SEPARATIONS.

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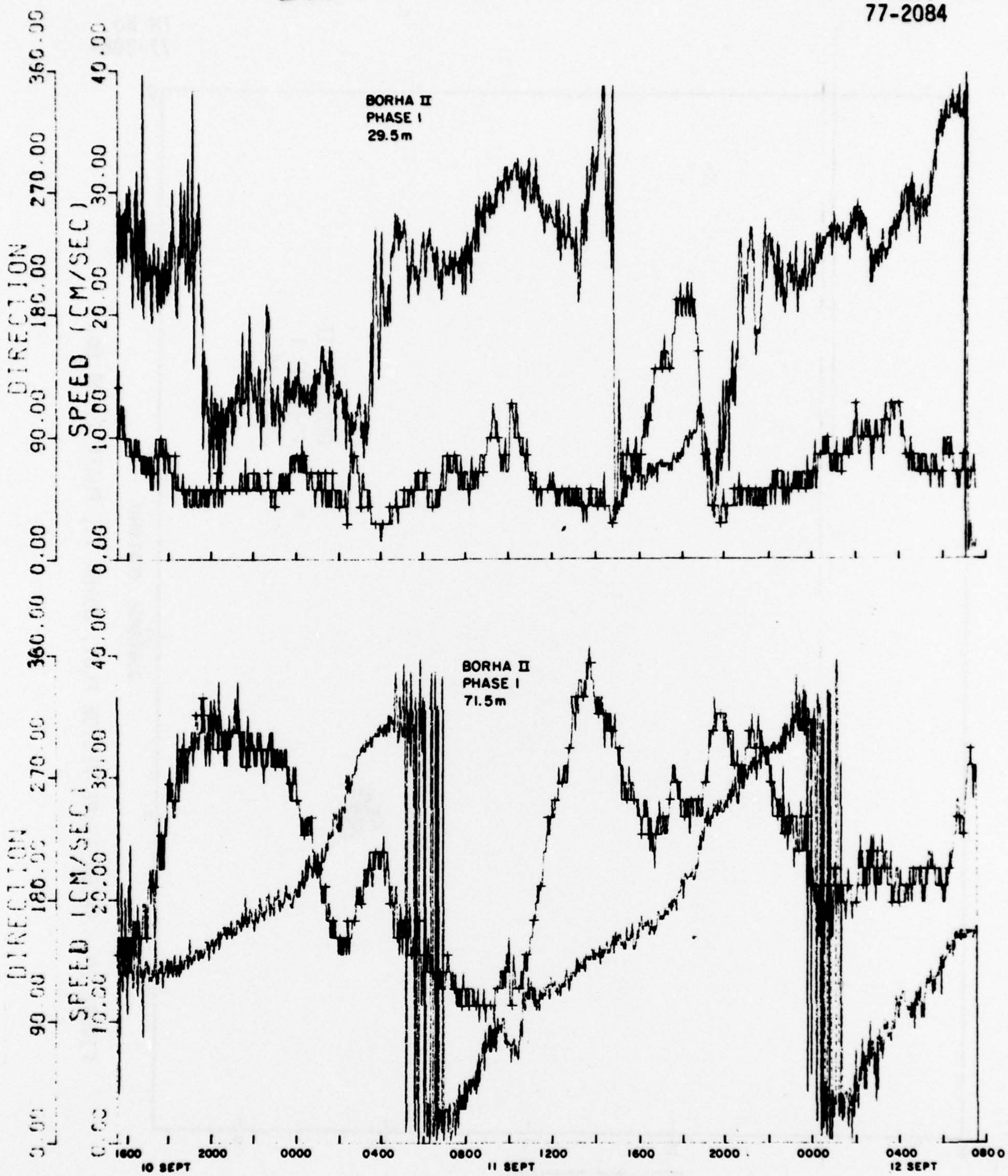

FIGURE 28. CURRENT SPEED AND DIRECTION, BORHA II, PHASE I.

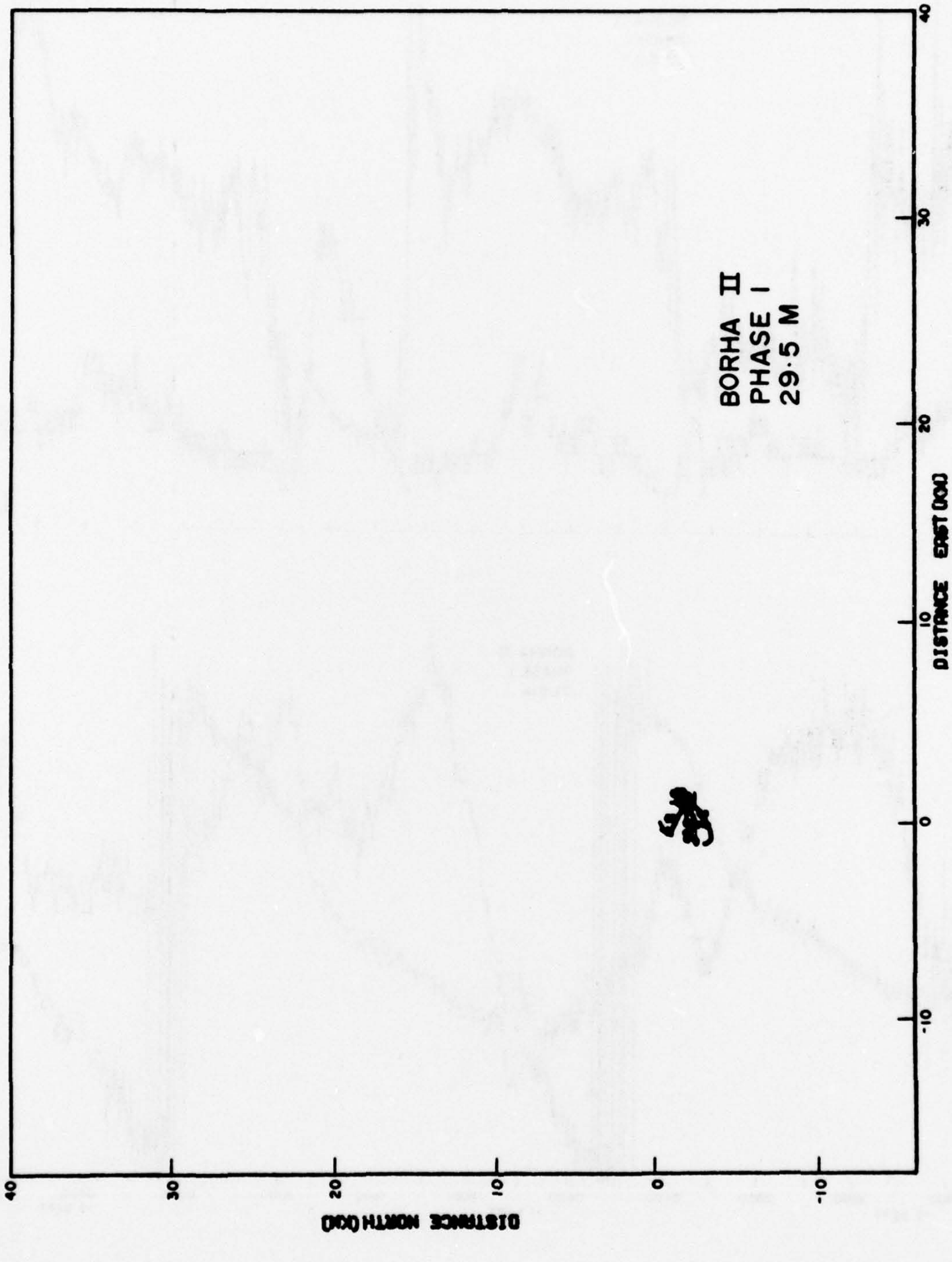

FIGURE 29. PROGRESSIVE VECTOR PLOT, BORHA II, PHASE I, 29.5m.

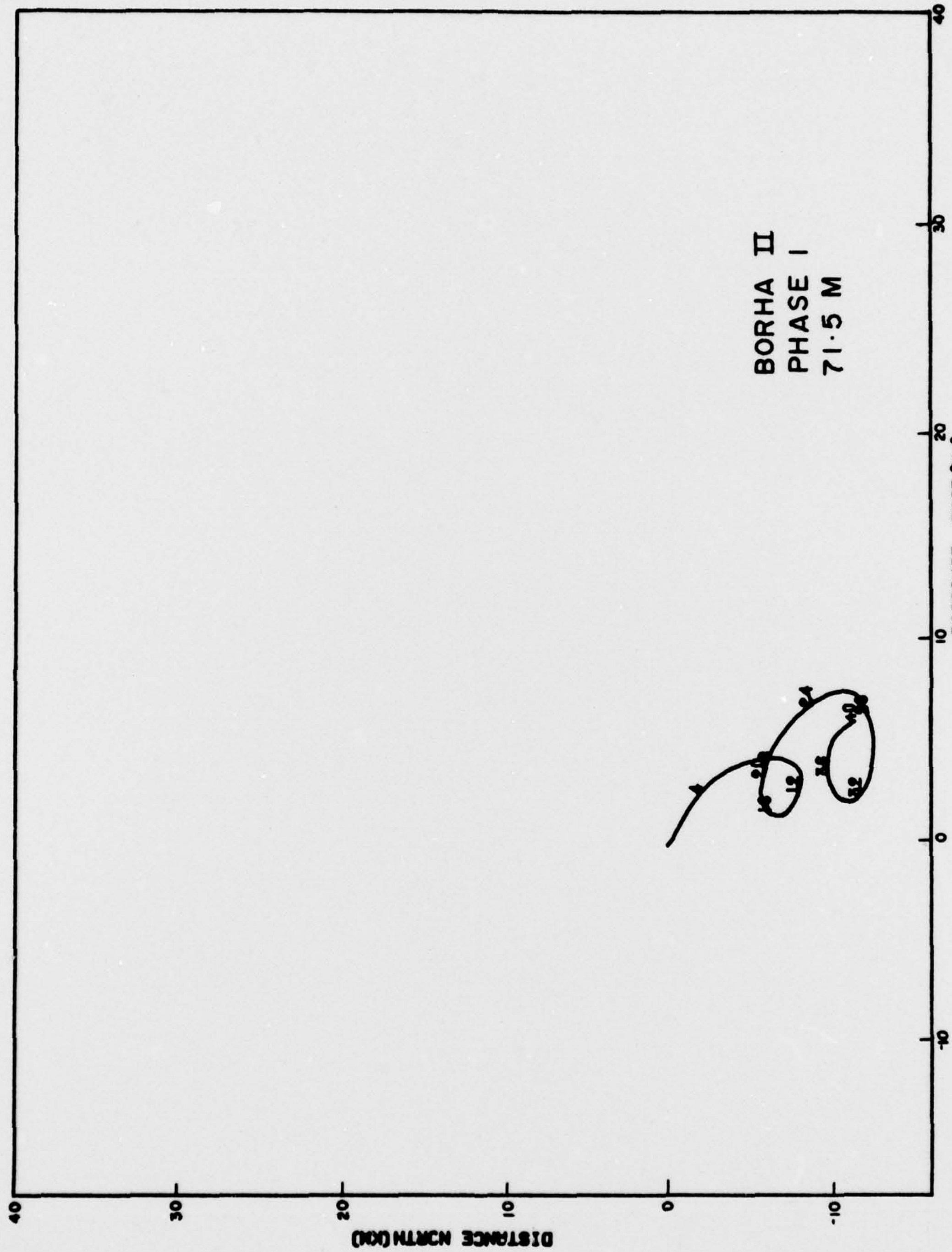

FIGURE 30. PROGRESSIVE VECTOR PLOT, BORHA II, PHASE I, 71.5m

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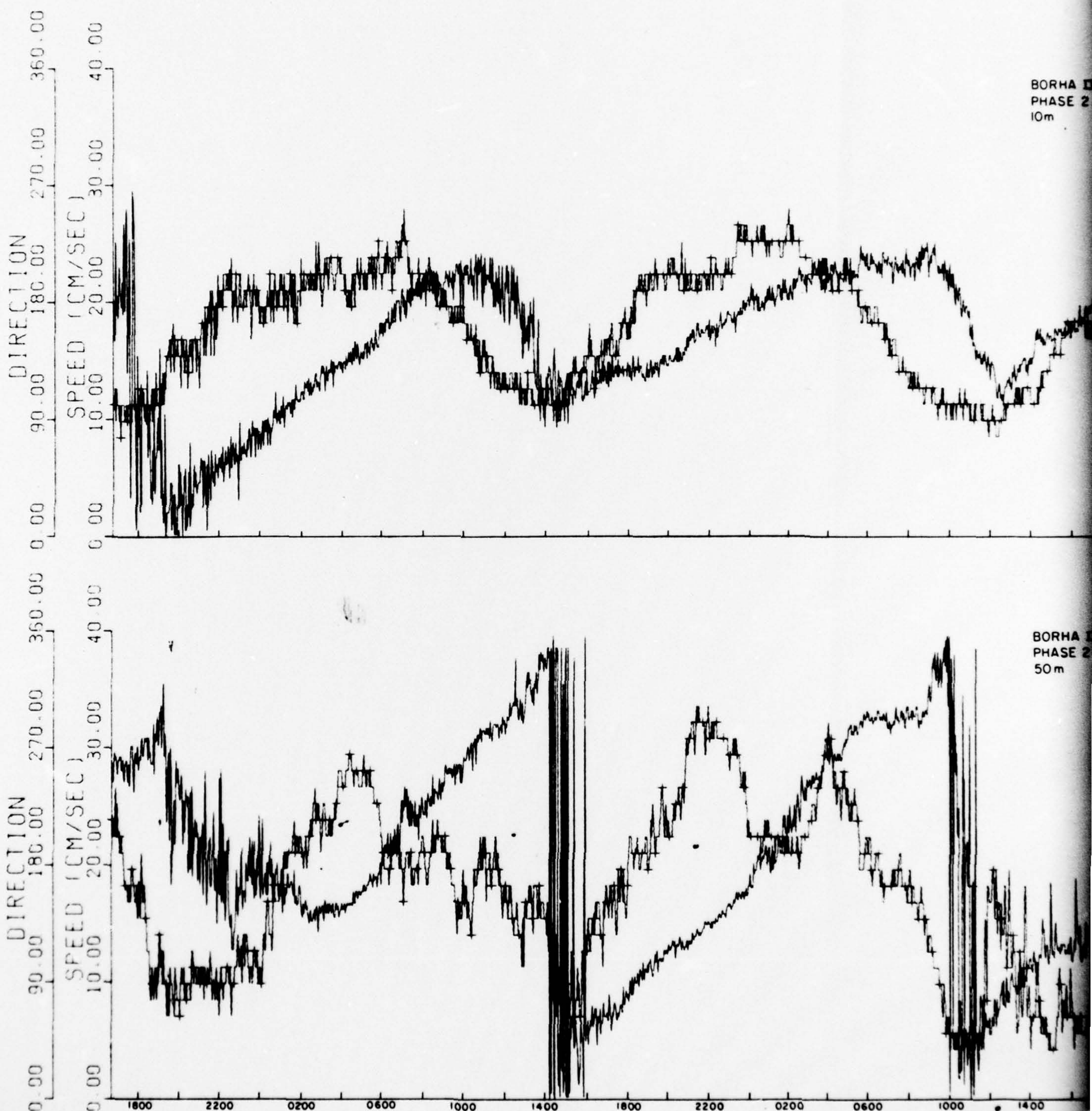
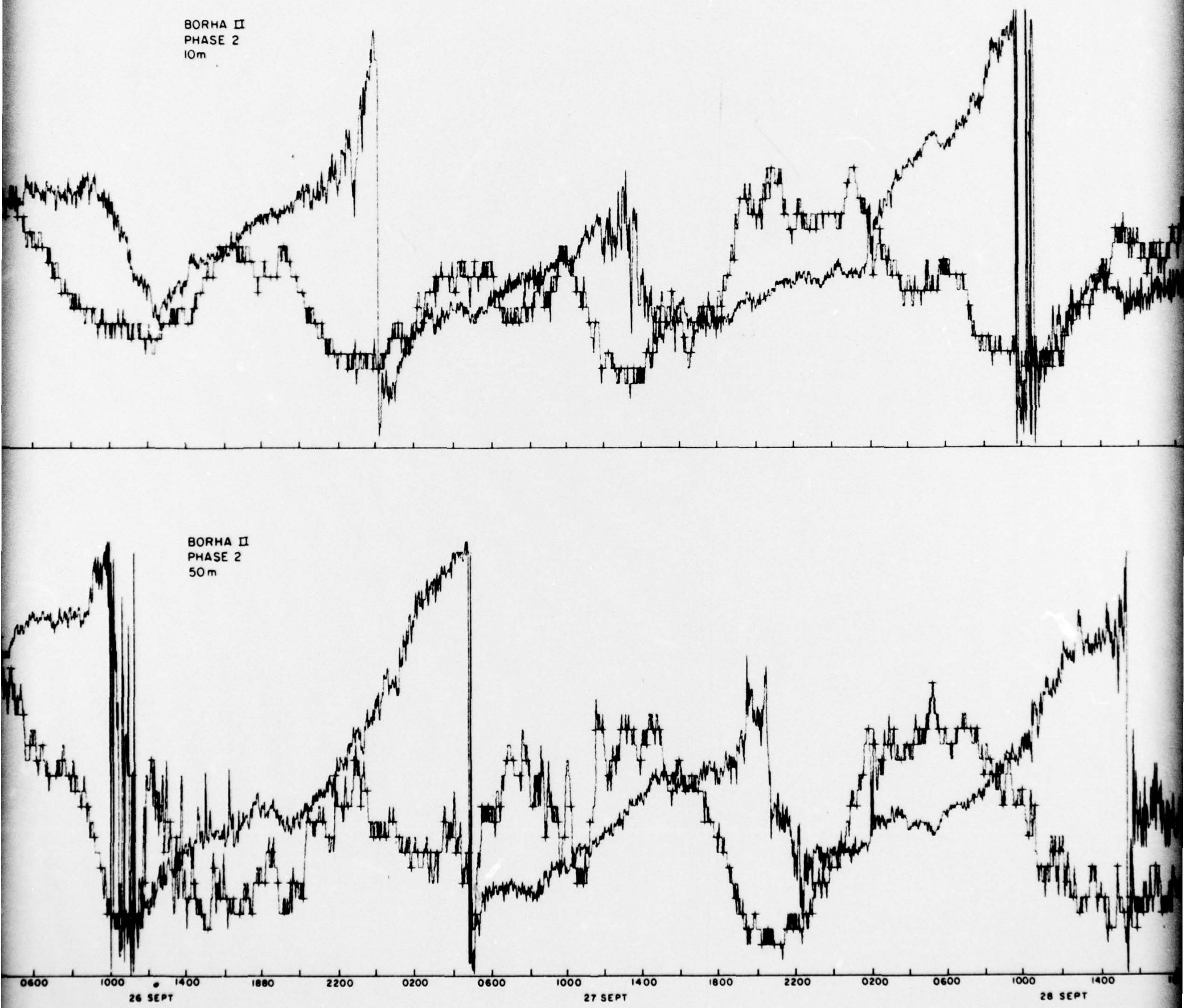


CURRENT SPEED AND DIRECTION, BORHA II, PHASE II.

2 1 1



BORHA II
PHASE 2
10m
BORHA II
PHASE 2
50m
0600
1000
1400
1880
2200
0200
0600
1000
1400
1800
2200
0200
0600
1000
1400
26 SEPT
27 SEPT
28 SEPT

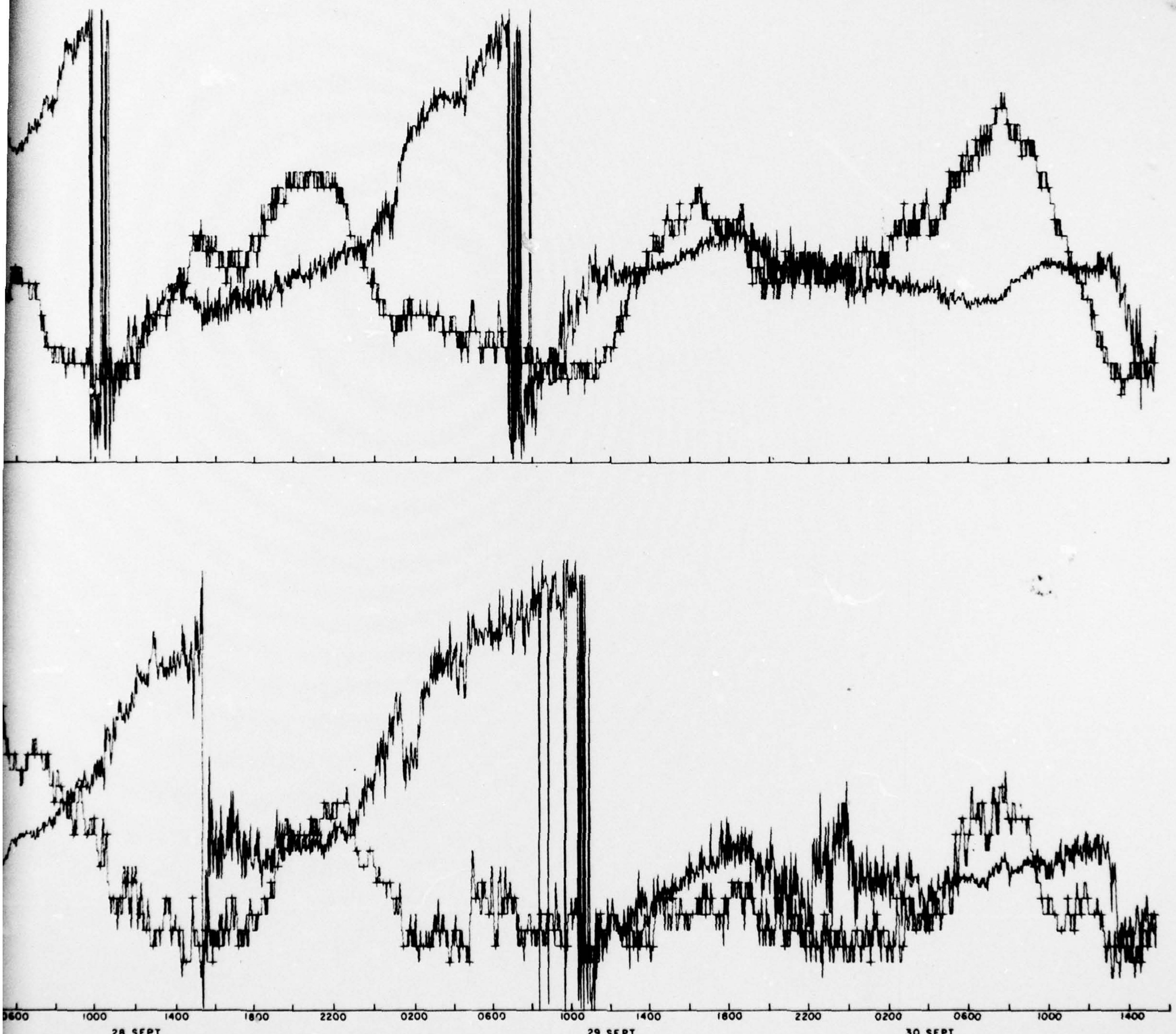

0600
1000
1400
1800
2200
0200
0600
1000
1400
1800
2200
0200
0600
1000
1400
28 SEPT
29 SEPT
30 SEPT

FIGURE 31

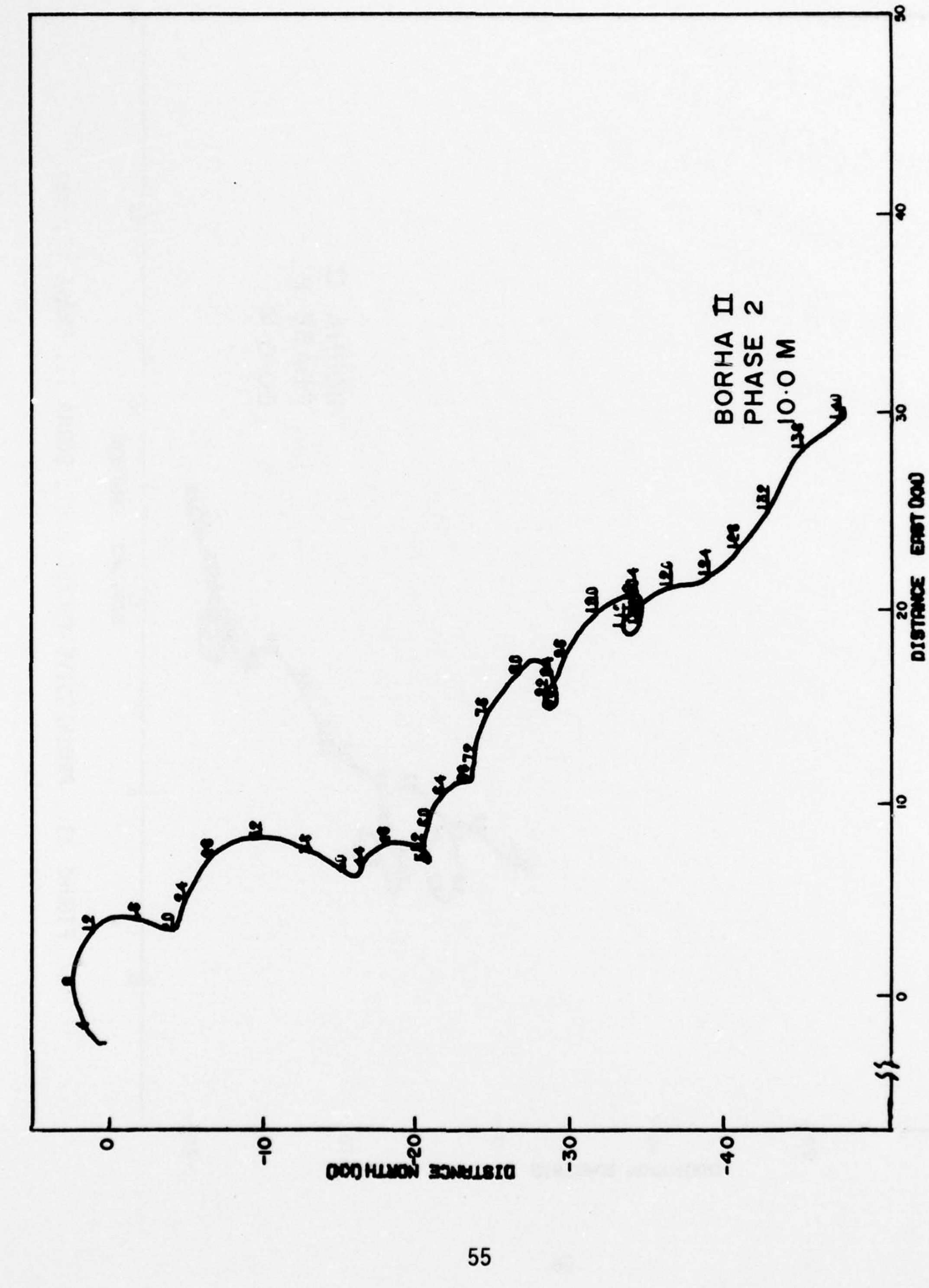


FIGURE 32. PROGRESSIVE VECTOR PLOT, BORHA II, PHASE II, 10m.

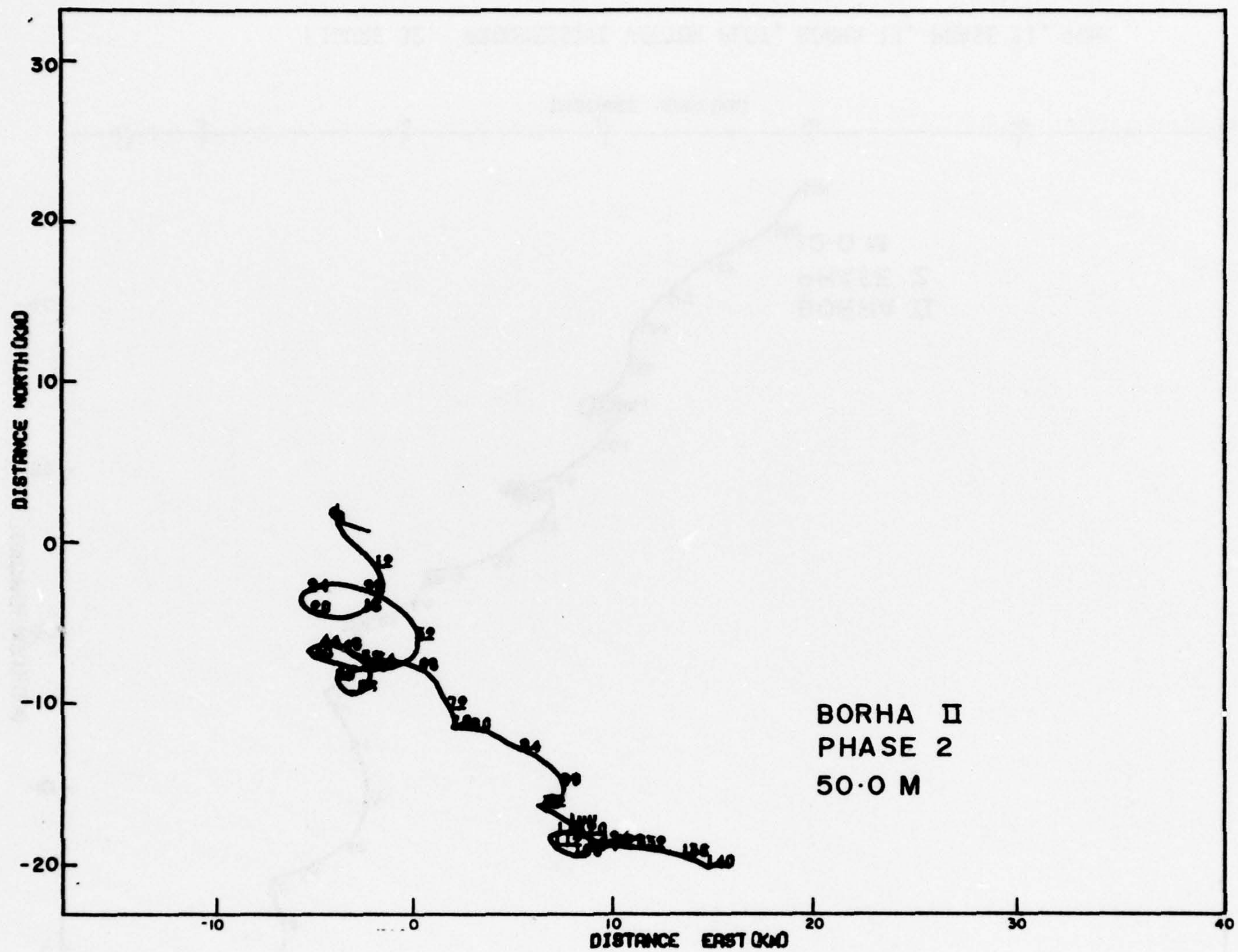


FIGURE 33. PROGRESSIVE VECTOR PLOT, BORHA II, PHASE II, 50m.

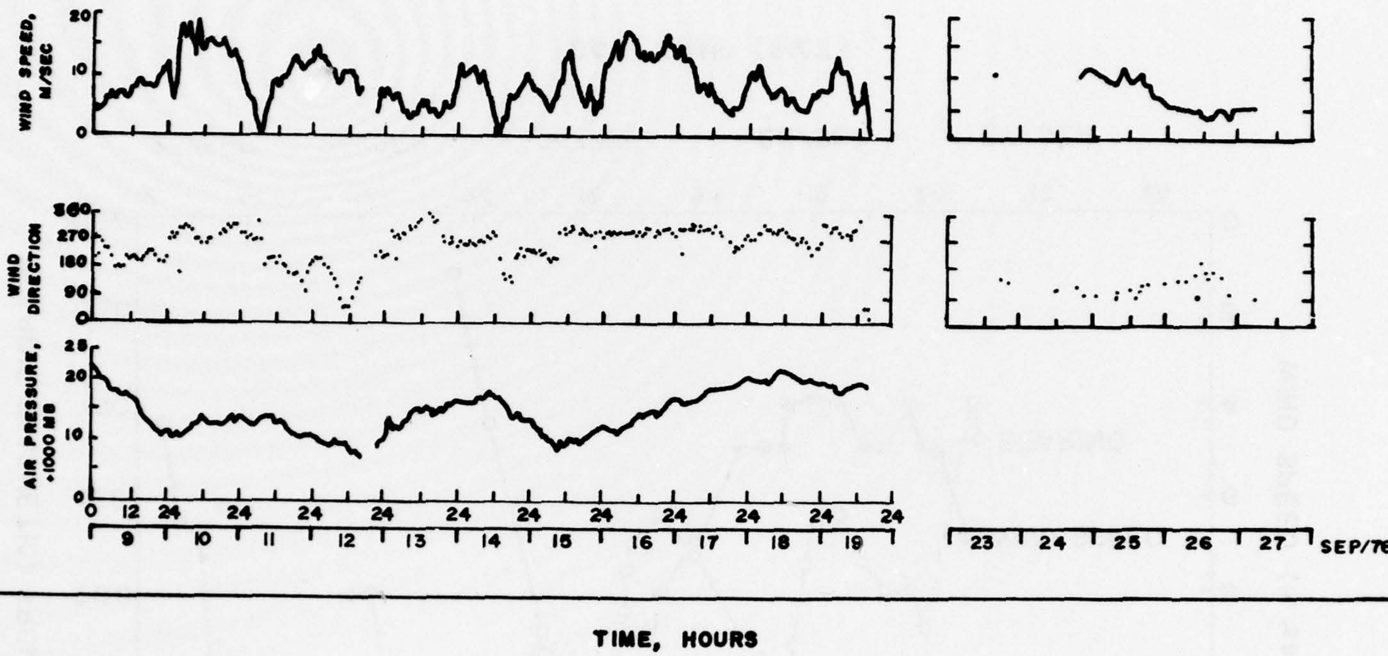


FIGURE 34. WIND SPEED AND DIRECTION, AND AIR PRESSURE MEASURED ON THE BORHA II.

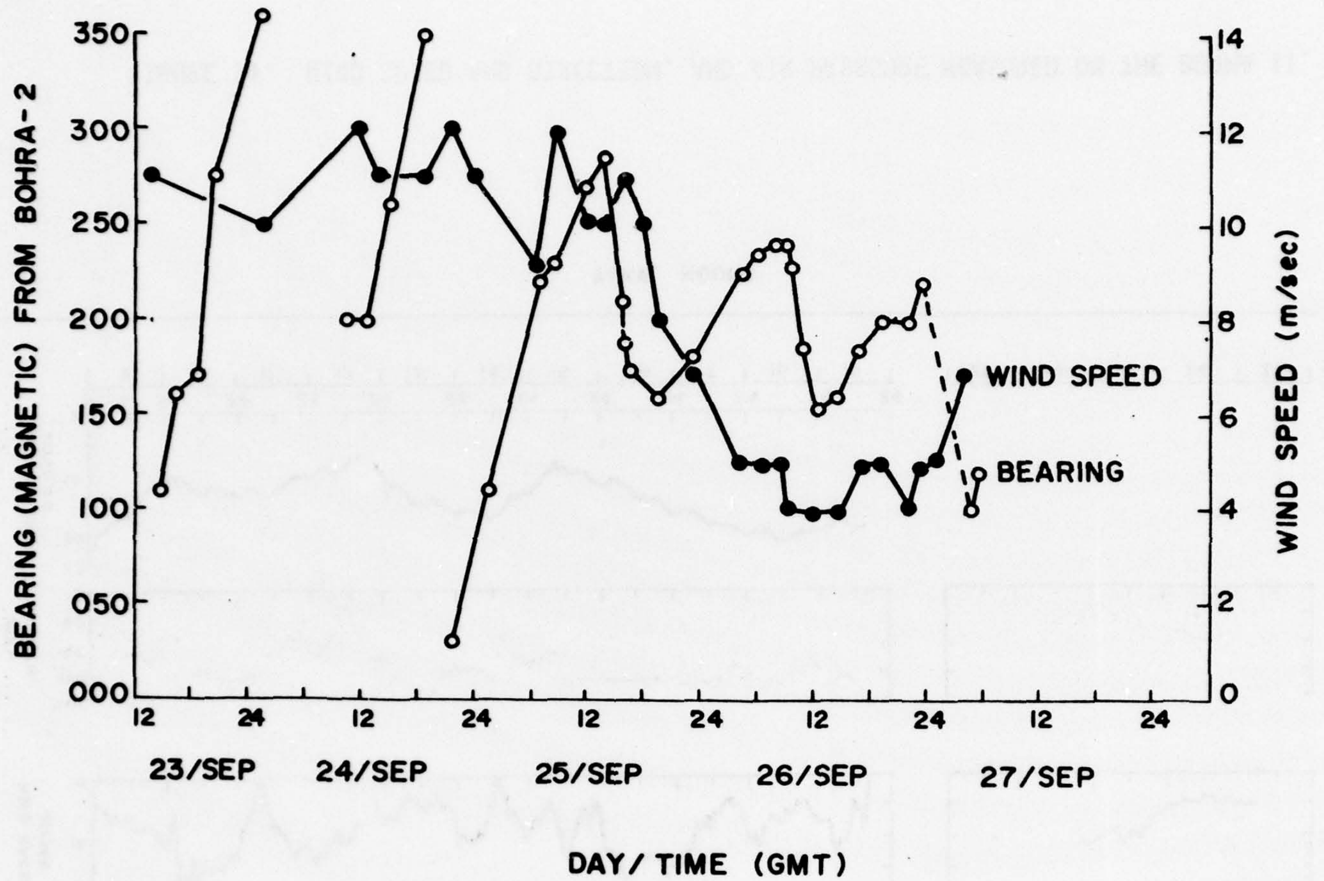


FIGURE 35. BEBE BORHA MAGNETIC BEARING AND WIND SPEED TIME SERIES.

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From 10-25/Sep/1976 upper ocean temperature and horizontal current measurements were made in the Gulf of Lyons, south of Toulon. Simultaneous moored data were obtained from the fixed oceanographic platform BORHA II and a satellite buoy tethered at horizontal separations from 100-1000m. In addition, time series of wind, other meteorological parameters, and vertical conductivity-temperature-depth profiles were obtained. The data set presented in this memorandum will be used to examine the upper ocean internal wave field and its relation to local forcing mechanisms.

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E.R. Levine, L. Goodman, D.H. Shonting
ASW Environmental Technology Group
Ocean Technology Division
TM No. 77-2084
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